

10 March 1999

MILITARY OPERATIONS RESEARCH SOCIETY



Mini-Symposium Report

Simulation Validation (SIMVAL) 1994

Dr. Marion L. Williams, FS

Mr. James J. Sikora

Co-Chairs

28-30 September 1994

BDM Federal, Inc.

Albuquerque, New Mexico

Dr. Julian I. Palmore
Proceedings Editor

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

101 South Whiting Street ♦ Suite 202 ♦ Alexandria, Virginia 22304-3416

(703) 751-7290 ♦ FAX: (703) 751-8171 ♦ email: morsoffice@aol.com

URL: <http://www.mors.org>

19990331 112

DISCLAIMER

This Military Operations Research Society Workshop proceedings faithfully summarizes the findings of a three-day meeting of experts, users and parties interested in the subject area. While it is not generally intended to be a comprehensive treatise on the subject, it does reflect the major concerns, insights, thoughts and directions of the authors and discussants at the time of the Workshop.

CAVEATS

The Military Operations Research Society does not make or advocate official policy.

Matters discussed or statements made during the Mini-Symposium were the sole responsibility of the participants involved.

The Society retains all rights regarding final decisions on the content of this workshop report.

REPORT DOCUMENTATION PAGE

*Form Approved
OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED	
	10 March 1999	Mini-Symposium Final Report 28-30 September 1994	
4. TITLE AND SUBTITLE Simulation Validation (SIMVAL) 1994 Mini-Symposium			5. FUNDING NUMBERS O & MN
6. AUTHOR(S) Christine M. Parnell, Editor Corrina Ross, Publisher			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Military Operations Research Society, Inc. 101 S. Whiting Street, Suite 202 Alexandria VA 22304-3416			8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Chief of Naval Operations, N81 Washington DC 20350-2000			10. SPONSORING/MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT Distribution Statement A: Approved for Public Release; Distribution Unlimited		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This publication is the final report of the Simulation Validation 1994 Mini-Symposium.			
14. SUBJECT TERMS		15. NUMBER OF PAGES i-x, 1-40, A-1-C-14	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UNLIMITED

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Sta. Z39-18
298-102

PTC QUALITY INSPECTED 2

SECURITY CLASSIFICATION OF THIS PAGE

CLASSIFIED BY:

DECLASSIFIED ON:

SECURITY CLASSIFICATION OF THIS PAGE

MILITARY OPERATIONS RESEARCH SOCIETY



Mini-Symposium Report

Simulation Validation (SIMVAL) 1994

Dr. Marion L. Williams, FS

Mr. James J. Sikora, FS
Co-Chairs

28-30 September 1994
BDM Federal, Inc.
Albuquerque, New Mexico

Dr. Julian I. Palmore
Proceedings Editor

101 South Whiting Street ♦ Suite 202 ♦ Alexandria, Virginia 22304-3416
(703) 751-7290 ♦ FAX: (703) 751-8171 ♦ email: morsoffice@aol.com
URL: <http://www.mors.org>

TABLE OF CONTENTS

The Military Operations Research Society	vii
Preface	ix
Executive Summary - Dr. Marion Williams, FS and Mr. Jim Sikora, FS	1
Chapter 1 - Introduction	7
Chapter 2 - Background of the SIMVAL Series	9
Chapter 3 - Working Group 1 - Campaign/Theater Level Models/Simulations	
Co-chairs Lt Col Robert Sheldon and Mr. Howard Whitley	11
Chapter 4 - Working Group 2 - Mission Level	
Co-chairs Ms. Cheryl Black and Mr. John Riente	15
Chapter 5 - Working Group 3 - Engagement Level M & S	
Co-chairs Mr. Robert Hartling and Mr. Mark Ralston WG 3A	
Co-chairs Dr. Paul Muessig and LCDR Michael Borowski WG 3B	19
Chapter 6 - Working Group 4A - ADS/DIS	
Advanced Distributed Simulation/Distributed Interactive Simulation	
Co-chairs - Dr. Julian Palmore and Mr. Robert Eberth	23
Chapter 7 - Working Group 4B - ADS/DIS	
Advanced Distributed Simulation/Distributed Interactive Simulation	
Co-chairs - William Dunn, and Mr. Rob Wright	27
Chapter 8 - Workshop Summary	33
Chapter 9 - Where Do We Go From Here?	37
Glossary of Abbreviations and Acronyms	39
Appendix A - Agenda	A-1
Appendix B - Terms of Reference	B-1
Appendix C – Participants	C-1

The Military Operations Research Society

The purpose of the Military Operations Research Society (MORS) is to enhance the quality and effectiveness of classified and unclassified Military Operations Research. To accomplish this purpose, the Society provides media for professional exchange and peer criticism among students, theoreticians, practitioners, and users of Military Operations Research. These media consist primarily of the traditional annual MORS Symposia (classified), their published proceedings, special mini-symposia, workshops, colloquia and special purpose monographs. The forum provided by these media is directed to display the state of the art, to encourage consistent professional quality, to stimulate communication and interaction between practitioners and users, and to foster the interest and development of students of operations research. In performing its function, the Military Operations Research Society does not make or advocate official policy nor does it attempt to influence the formulation of policy. Matters discussed or statements made during the course of its Symposia or printed in its publications represent the positions of the individual participants and authors and not of the Society.

The Military Operations Research Society is operated by a Board of Directors consisting of 30 members, 28 of whom are elected by vote of the Board to serve a term of four years. The persons nominated for this election are normally individuals who have attained recognition and prominence in the field of Military Operations Research and who have demonstrated an active interest in its programs and activities. The remaining two members of the Board of Directors are the immediate Past President who serves by right and the Executive Vice President who serves as a consequence of his position. A limited number of Advisory Directors are appointed from time to time, usually for a one-year term, to perform some particular function. Since a major portion of the Society's affairs is connected with classified services to military sponsors, the Society does not have a general membership in the sense of other professional societies. The members of MORS are the Directors, persons who have attended a MORS meeting within the past three years and Fellows of the Society (FS) who, in recognition of their unique contributions to the Society, are elected by the Board of Directors for life.

MORS is Sponsored* by:

- The Deputy Under Secretary of the Army (Operations Research)
- The Director, Assessment Division, Office of the Chief of Naval Operations
- The Director of Modeling, Simulation and Analysis, Deputy Chief of Staff, Air and Space, Plans and Operations, Headquarters, US Air Force
- The Commanding General, Marine Corps Combat Development Command
- The Director of Force Structure, Resource and Assessment, The Joint Staff
- The Director Program Analysis and Evaluation, Office Secretary of Defense

* As of September 1994

PREFACE

The Simulation Validation (SIMVAL) series of Workshops and Mini-Symposia started in October 1990 in Albuquerque NM. I attended the original Workshop and SIMVAL II in 1992. As a participant in SIMVAL '94 and a Co-Chair of Working Group (WG) 4A on Advanced Distributed Simulation (ADS), I feel these discussions on Verification, Validation and Accreditation (VV&A) have served a fine purpose in alerting the Military Operations Research Community to a need to regularize discussions on these topics. The topics of VV&A have achieved recognition in the defense community with DoD, the Joint Staff and the Services issuing directives and instructions on how to make VV&A happen on a regular basis. This is a tangible sign that MORS has succeeded very well.

The Executive Summary was written originally by Jim Sikora, FS and Marion Williams, FS as an article for the December 1994 issue of *PHALANX* and is reproduced in its entirety here. These Proceedings expand on that material by presenting in detail the summaries of the several working groups.

In September 1994, at the time of the SIMVAL '94, DIS was the most notable example of ADS and WG 4A and 4B devoted considerable attention to it. DIS has been superceded by the High Level Architecture (HLA) and currently is in widespread use at the time of this publication.

Julian Palmore
Editor
April 1997

EXECUTIVE SUMMARY

SIMVAL Co-Chairs: Dr. Marion L. Williams, FS and Mr. James J. Sikora, FS

This publication is the proceedings of the Military Operations Research Society (MORS) Simulation Validation (SIMVAL) Workshop held 28-30 September 1994 in Albuquerque, New Mexico (SIMVAL '94). SIMVAL '94 was hosted by BDM International and the Air Force Operational Test and Evaluation Center. The Workshop was one of the SIMVAL series on Modeling and Simulation (M&S) Verification, Validation and Accreditation (VV&A). It was specifically structured to address the theme "How Much V&V (Verification and Validation) is Enough?" These Proceedings contain the findings of the working groups as well as a summary of those findings.

Chapter 1, "*Introduction*," provides the purpose of the Workshop, the four key questions which were discussed and answered in order to address the theme and the overall approach to the Workshop organization and procedures. Chapter 2, "*Background of the SIMVAL Series*," provides a brief history of the SIMVAL series and a description of its previous work. Working group (WG) summaries are provided in Chapters 3 through 7. Each chapter contains a summary of the findings of a WG relative to the four key questions. The WG summaries were taken from annotated briefings. The briefings were developed by the working group co-chairs and presented during the last session of the workshop. Chapter 8, "*Workshop Summary*," integrates the findings of all of the working groups into a single set of responses to the four key questions. Chapter 9, "*Where Do We Go From Here?*" provides a summary of the recommendations from the SIMVAL Senior Advisory Group (SAG) meeting that was held immediately after the SIMVAL '94 Workshop concluded.

It is a basic premise of the SIMVAL series that its findings represent a consensus of the military and the military support community. These Workshop findings represent such a consensus. It is built not only on the work of the attendees, but on the efforts of several hundred other participants in previous SIMVAL activities

during the past four years. We owe a great deal of gratitude to all these people for their hard work and dedication. Their effort will not have been in vain — if the community will use their findings as a basis for implementing VV&A policies and procedures and in specific VV&A applications.

I. SIMVAL Background

The first effort, a Mini-Symposium held in Albuquerque, New Mexico 15-18 October 1990, was hosted by the Air Force Operational Test and Evaluation Center and BDM International. It provided a forum for discussing ongoing activities in model validation and served as a basis for planning future efforts.

Objectives of the Mini-Symposium were to:

- Review current efforts in simulation validation.
- Support technical interchange on simulation validation.
- Agree on a consistent set of definitions for terms such as "validation," "verification," "accreditation," etc.
- Develop a plan for future efforts to address issues of simulation validation.

At this Mini-Symposium, a set of definitions was adopted, and later approved by the MORS Sponsors. These definitions have been accepted by the Services and OSD, and have provided the basis for much of the VV&A policies now in use throughout DoD.

The definitions adopted at that conference were:

- *Verification.* The process of determining that a model implementation accurately represents the developer's conceptual description and specifications.

- *Validation.* The process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model.
- *Accreditation.* An official determination that a model is acceptable for a specific purpose.

At subsequent Workshops, the elements of VV&A were defined. These included the following:

- *Code Verification.* This consists of a rigorous audit of the code to ensure proper implementation, accomplished by both the developer and an independent IV&V agent.
- *Comparison to Intelligence Data.* Comparison of the model output with collected intelligence data or intelligence analyses.
- *Comparison with Developmental Data.* Comparison of common measures in the model to those obtained in a test of the system under laboratory or controlled test conditions. (This provides a way of understanding or calibrating the model results where appropriate)
- *Comparison with Operational Data.* Comparison of the model output with results of field exercises, operational tests or actual system or combat results.
- *Configuration Management.* A discipline applying technical and administrative oversight and control to identify and document the functional requirements and capabilities of a model, control changes to those capabilities and document and report the changes. Configuration management includes ensuring the detailed design and the computer source code of the model are properly documented. This should be accomplished in conjunction with the model developer.
- *Data Verification.* Review of the sources of data and consistency of definition of how data were collected (conditions, limitations, etc.) along with a definition of how the data are used in the model.
- *Data Validation.* Comparison of model input data to the corresponding known real world or best estimate values. This is typically done by the model user.
- *Documentation.* Analyst's manual, user's guide, programmer's manual etc., providing the math, program structure, assumptions and algorithms used. This also includes documentation of procedures and results of any VV&A efforts.
- *Face Validation.* The process of determining whether a model, based on performance, seems reasonable to people who are knowledgeable about the system under study. ("Simulation Modeling and Analysis," Law and Keaton, McGraw-Hill). This process applies the knowledge and understanding of experts in the field. It can be accomplished inexpensively and in a reasonably short time. It is, however, subject to the biases and weaknesses of the experts involved.
- *Independent Review.* Examination of all steps in the validation process by an agent independent of the model developer. Subject to the competence and independence/objectivity of the reviewer.
- *Logical Verification.* The identification of a set of assumptions and interactions for which the model correctly produces intended results. Logical verification determines the appropriateness of the model for a particular application. This is accomplished by the model designer or the developer's IV&V agent.

- *Sensitivity Analyses.* Using the full range or maximum, minimum and high probability values, of major model variables in model exercises to assure correct, corresponding changes in model output.

II. SIMVAL '94

The objective at SIMVAL '94 was to address the question: "How Much V&V is Enough?" We have established that V&V are necessary, and that accreditation is the decision that the V&V of a particular model is sufficient for a specific application. Now how much V&V is necessary considering such factors as level of model, type of decision, etc.?

This major issue was addressed through four key questions:

1. ACCREDITATION TEMPLATE

- Can a template be developed to support accreditation?**
- What would such a template look like?**
- How should we go about developing such a template?**

2. V&V STATUS

- How do we present the V&V status of a M&S?**
- Are there "units" of V&V?**

3. ACCREDITATION FACTORS

What factors should we use to determine whether to accept a M&S (or its results)?

4. LEGACY M&S

- What is a legacy model?**
- Does a legacy M&S acquire any V&V credibility by its use and acceptance?**

c. Do we V&V a legacy M&S any differently than any other M&S?

Four SIMVAL '94 working groups were established to address the issue and four key questions. Each WG represented a different type of models: campaign level, mission level, engagement level and Distributed Interactive Simulation (2 WGs).

1. a. Can a template be developed to support accreditation?

All working groups agreed that an accreditation template could be developed. They agreed that one template was not possible; there should be a family of templates based on M&S level, application type and use. A composite of the working groups' conclusions include the following in the template:

A. Application Description

1. Purpose of application
2. Objectives
3. Specific issues/concerns
4. Application risk/importance
5. Time required for accreditation
6. Resource constraints

B. Accreditation Basics

1. M&S description (Title, M&S scope/overview, version)
2. M&S proponent (reputation/experience)
3. Proposed use in decision process (integration with other methods/data)
4. Key functional representations
5. V&V status (including credentials of V&V agents)
6. Sensitivity analyses performed
7. Known limitation/constraints
8. Configuration management/control
9. Documentation available
10. Data
 - a. Sources
 - b. Verification status
 - c. Validation status
 - d. Certification
 - e. Uncertainty

11. Affordability considerations.
12. Availability of M&S and trained, experienced users
13. Risk reduction actions
14. Alternatives considered
15. Historical use, acceptance, known applications (including any DIS use)
16. Previous accreditation history (including any DIS use)

C. Assessment Approach

1. Acceptance criteria (by key functional representation)
2. Priority sequence of key functions for V&V (useful if under a time or resource constraints)
3. Methodology for meeting criteria
 - a. Verification plan
 - b. Validation plan
 - c. DIS considerations (if a distributed interactive simulation)
 - d. Impact on application of M&S functions not verified
 - e. Impact on application of M&S functions not validated

D. Recommendations/Options

1. Actions taken (if any)
2. Caveats, by functional representation

E. Decision

The accreditation decision maker should consider all of these factors before accepting an M&S or its results, but the degree to which they are considered is a function of the application risk/importance as well as resource and time constraints. The development of guidelines for determining the degree, or how much is enough, is addressed in Section III below.

The group agreed that were no quantifiable units for V&V. They also said that if any such units were developed, they would likely be misused.

2. a. How do we present the V&V status of a M&S?

Another issue addressed at the workshop was a methodology for presenting the V&V status of a M&S application. The working groups generally agreed that verification and validation status should be reported separately. The status would be conveyed by the following:

A. Strategic Indicators

1. Age/maturity
2. Level of configuration management
3. Size of user group
4. Major versions/pace of change
5. Number of applications/studies supported
6. Data sources
7. Functional adaptability

B. Verification Status

1. Key functions/elements/interactions
2. For each key function/element/interaction
 - a. Verification method used
 - b. M&S version to which applied, with linkage to current version
 - c. Date of application
 - d. Verification agent
 - e. Verification report reference
 - f. Verification results (quantitative statements)
 - g. Verification conclusions (quantitative statements)

C. Validation Status

1. Key functions/elements/interactions
2. For each key functions/element/interaction
 - a. Validation method used
 - b. M&S version to which applied, with linkage to current version
 - c. Date of application
 - d. Validation agent
 - e. Validation report reference
 - f. Validation results (quantitative statements)
 - g. Validation conclusions (quantitative statements)

D. Limitations/Risks

4. **What Are Accreditation Factors?** The factors are shown in the accreditation template of question 1.
5. **How do we VV&A a "legacy" M&S?** As an additional topic, the working groups addressed the issue of "legacy" M&S. Although there was no definition of a legacy model, most agreed that a legacy M&S was one with a long history of use with moderate or high levels of V&V and broad acceptance in the community. The working groups basically agreed that legacy M&S accrued credibility by use over time, but should go through the same processes for VV&A as any other M&S. It should have a larger data base of historical use and VV&A from which to draw, thereby making an accreditation decision easier or quicker.

III. SIMVAL Guidance on SIMVAL '94 Results

At the SIMVAL SAG meeting held following SIMVAL '94, it was agreed to use the output of the Workshop to draft a set of VV&A templates. The result will be a set of guidelines for application and model types. These guidelines will be put on an electronic bulletin board to be developed by MORS. This will allow individuals to comment on, and make changes to, the guidelines. At a time when there seems to be general consensus, these guidelines will be published. It was generally agreed that no additional SIMVAL Workshops should be planned until the community has had time to use VV&A guidelines developed by the SIMVAL series in case studies. At some future date, a workshop to discuss these case studies would be beneficial.

CHAPTER 1

INTRODUCTION

A. Purpose of Workshop

The SIMVAL '94 Workshop was one in a series of MORS activities focused on the area of Model and Simulation (M&S) Verification, Validation and Accreditation (VV&A). The overall purpose of all SIMVAL series activities is to bring interested members of the MOR/M&S community together to discuss current VV&A problems and issues, and to develop by consensus, solutions, approaches and recommended practices to address these problems and issues.

The purpose of the SIMVAL '94 Workshop was to address the theme, "How much V&V is enough?" The "enough" in the theme implies for an accreditation decision to accept a M&S or its results. The theme was addressed through consideration of four key questions.

B. The Key Questions

Four key questions which consider different aspects of the theme were the basis of Workshop discussion. The questions are:

1. ACCREDITATION TEMPLATE

- a. Can a template be developed to support accreditation?**
- b. What would such a template look like?**
- c. How should we go about developing such a template?**

2. V&V STATUS

- a. How do we present the V&V status of a M&S?**
- b. Are there "units" of V&V?**

3. ACCREDITATION FACTORS

What factors should we use to determine whether to accept a M&S (or its results)?

4. LEGACY M&S

- a. What is a legacy model?**
- b. Does a legacy M&S acquire any V&V credibility by its use and acceptance?**
- c. Do we V&V a legacy M&S any differently than any other M&S?**

C. The Workshop Approach

The approach to the Workshop was to:

- Set the context of discussions by reviewing the history/previous findings of the SIMVAL series. This was accomplished by sending out a section of the previous SIMVAL Workshop proceedings as read-ahead material and by a short briefing to start the SIMVAL '94 Workshop.
- Give an overview of the current Marine Corps, OSD (PA&E) and the government Accounting Office (GAO).
- Break up into small working groups for discussion.
- Discuss approaches/solutions to the four key questions.
- Summarize the findings of each working group and present the summary to all attendees.

The Workshop attendees were organized into four major groups based on types of M&S. The four groups were:

- 1. Campaign/Theater Level**
- 2. Mission Level**

3. Engagement Level
4. Advanced Distributed Simulation(ADS)/
Distributed Interactive Simulation (DIS)

Attendees were assigned to working groups based on individual preferences given on attendance application forms. Because of the large interest in Engagement Level and Advanced Distributed Simulation, these working groups were divided into two sections each (3A, 3B, 4A and 4B). The working groups discussed the four key questions from the perspective of their assigned type of M&S. Each WG or section was led by two co-chairs. The co-chairs are listed below.

After the working groups met for the first time, the two sections of group 3 (3A and 3B) decided they would operate as a single working group. Some of the working groups began their discussions with case study briefings in their area. The WG co-chairs led their assigned attendees through consideration of each of the four key questions. At the end of the discussion period, the findings for each question were summarized and developed into a WG summary briefing. Each working group presented their individual summary briefing at the end of the Workshop.

WG1 CAMPAIGN/THEATER LEVEL MODELS/SIMULATIONS

Lt Col Robert Sheldon, USAF
Mr. Howard Whitley

WG2 MISSION LEVEL

Ms. Cheryl Black
Mr. John Riente

WG3A/B ENGAGEMENT LEVEL M&S

Mr. Robert Hartling (WG3A)
Mr. Mark Ralston (WG3A)
Dr. Paul Muessig (WG3B)
Mr. Michael Borowski (WG3B)

WG4A (ADS/DIS) ADVANCED DISTRIBUTED SIMULATION/DISTRIBUTED INTERACTIVE SIMULATION

Dr. Julian Palmore
Mr. Robert Eberth

WG4B (ADS/DIS) ADVANCED DISTRIBUTED SIMULATION/DISTRIBUTED INTERACTIVE SIMULATION

Mr. William Dunn
Mr. Rob Wright

CHAPTER 2

BACKGROUND OF THE SIMVAL SERIES

MORS has sponsored a series of activities on "Simulation Validation." (SIMVAL) as shown in Table 2-1. The first activity, a mini-symposium held in Albuquerque, New Mexico, October 15-18, 1990, was hosted by the Air Force Operational Test and Evaluation Center and BDM International Inc. The Mini-Symposium provided a forum for general discussion of the broad topic of simulation VV&A and served as a basis for planning future efforts.

Objectives of the Mini-Symposium were to:

- Develop consensus on a consistent set of definitions for terms such as "verification," "validation" and "accreditation," etc.,
- Develop a plan for future efforts to address issues of simulation validation.

The Mini-Symposium was divided into five major sessions: Requirements Analysis, System Design, Operational Test and Evaluation, Operations Support and Tactics Development and Training.

TABLE 2-1 SIMULATION VALIDATION SERIES ACTIVITIES

13 February 1990 14 June 1990	SAG Meeting 1 - Planning 58th MORSS - Preliminary community discussion on series (WG 28)
15-18 October 1990	MINI-SYMPOSIUM I
16 October 1990	SAG Meeting 2 - Review/discuss definitions/roadmap
18 October 1990	SAG Meeting 3 - Establish definitions (V,V & A), update roadmap
12-13 December 1990 7 February 1991	AD HOC Working Group I - Validation methodology SAG Meeting 4 - Review/discuss accreditation, update roadmap
20 March 1991 11-13 June 1991 17 September 1991	SAG Meeting 5 - Review/discuss VV & A 59th MORSS - Summary of findings/status report SAG Meeting 6 - Develop monograph approach/workshop structure
31 March - 2 April 1992 23-25 Jun3 1992	SIMVAL II WORKSHOP - Review methods, develop basis for monograph 60th MORSS - Summary of findings/status report in General Session
3 March 1993	SAG Meeting 7 - Review monograph approach/update roadmap
18 November 1993	SAG Meeting 8 - Develop approach to SIMVAL 94 WORKSHOP
28-30 September 1994 30 September 94	SIMVAL '94 WORKSHOP SAG Meeting 9 - Determine future directions

- Review current efforts in simulation validation.
- Support technical interchange on simulation validation.

Papers for these sessions included case histories, methodologies, lessons learned and status of current simulation validation efforts.

A SAG, composed of senior analysts representing a breadth of simulation experience, was formed to provide guidance in planning the Workshop

series, to assist in developing a consistent set of definitions, and to develop a roadmap of activities necessary to arrive at a consensus on a model validation process. The SAG membership is shown in Table 2-2. The goal of the SAG was to arrive at a consistent set of definitions for simulation verification, validation and accreditation which would be agreeable to all DoD components, thus resolving the problems caused by the current use of different definitions.

The SAG recommended a subsequent meeting to provide a better description of the validation methodologies. To accomplish this, an ad hoc WG meeting was held at the MITRE Corporation on 12-13 December 1990, with DoD component and industry representatives. The purpose of the meeting was to attempt to define elements of a validation process. Experts in five different types of application areas were invited: force planning and operations, acquisition, test and evaluation, training and deployment, mobilization and sustainability.

SIMVAL II, another Workshop of the SIMVAL series was held 31 March - 2 April 1992, at the Institute for Defense Analyses (IDA). At this Workshop, model VV&A case studies were discussed, and examples were mapped into the VV&A elements defined at previous meetings. The concept was to use the most pertinent portions of the case studies as examples of specific elements of VV&A.

TABLE 2-2 SENIOR ADVISORY GROUP MEMBERS

Dr. Marion Williams, FS, (Co-chair)	AFOTEC
Jim Sikora, FS, (Co-chair)	BDM International
Dr. David Anderson	USAFSAA
Dr. Paul Davis	RAND
Dr. Hank Dubin	USA OPTEC
Jim Duff	USN OPTEVFOR
Bill Dunn	USA MISMA
Christine Fossett	GAO
Dr. Saul Gass	Univ of MD
Dr. Dale Henderson	LANL
Dr. Ron Hofer	USA STRICOM
Dr. Mort Metersky	USN NADC
Allen Murashige	USAF SAA
Jim O'Bryon	OSD, T&E/L&MP
Dr. Dale Pace	JHU/APL
Nelson Pacheco	IDA
Dr. Julian Palmore	Univ of IL
John Riente	DSMC
Kathleen Ruemmele	BMDO
Dr. Pat Sanders	OSD PA&E
Dr. Ernest Seglie	OSD DOT&E
Dennis Shea	CNA
Clay Thomas, FS	USAF SAA
Gene Visco, FS	USA MISMA
Mark Zabek	IDA

CHAPTER 3

WORKING GROUP 1

CAMPAIGN/THEATER LEVEL MODELS/SIMULATIONS

Co-chairs: Lt Col Robert Sheldon and Mr. Howard Whitley

This is a report of the activities, discussions and results of WG 1, SIMVAL '94. Answers to the following questions were addressed.

1. ACCREDITATION TEMPLATE

- a. Can a template be developed to support accreditation?**
- b. What would such a template look like?**
- c. How should we go about developing such a template?**

2. V&V STATUS

- a. How do we present the V&V status of a M&S?**
- b. Are there "units" of V&V?**

3. ACCREDITATION FACTORS

What factors should we use to determine whether to accept a M&S (or its results)?

4. LEGACY M&S

- a. What is a legacy model?**
- b. Does a legacy M&S acquire any V&V credibility by its use and acceptance?**
- c. Do we V&V a legacy M&S any differently than any other M&S?**

The WG responded to the questions relating to the possibility of developing templates to support accreditation decisions as follows. The group agreed that such templates can be developed. The template must require

consideration of the scenario in the application, the quality of data available to describe such parameters as lethality, vulnerability, etc., the experience of analysts using the model or simulation in the application as well as detailed information on the M/S. Important issues that should be addressed are acceptability criteria, methodology for meeting criteria, results and indicated actions and accreditation degrees: provisional (with caveats, by functional representation) and final (credibility of result). This suggests the possibility that often full accreditation may not be recommended until either the study is well underway or completed. A provisional accreditation, with caveats regarding certain functional representations, might be granted pending either receipt of more complete information or completion of the analysis. In the latter instance the credibility of results might result in a final accreditation decision. While the WG feels it has listed many of the most important M/S specific points in putting together a template, there are probably other important items that must be included, so the best template would evolve over time and application as more experience in VV&A is achieved.

2. a. How do we present the V&V status of a M&S?

- b. Are there "units" of V&V?**

Regarding the presentation of the V&V status of a M/S, there was full agreement that a single number would not suffice — that it could not reflect enough information to be useful in any decision. The group felt that a set of "strategic indicators" should be developed, that a list of methods used in verification activities as well as the findings would best describe verification status. That the validation activities carried out

be listed, and a statement of known M/S limitations and associated risks be provided for consideration in any accreditation decision. Note that these are mostly qualitative assessments and statements.

More details on the strategic indicators, or "pedigree," are listed below in Table 3-1. Although it is not yet complete, Table 3-1 reflects the concern that the complete background be open for review. For older M/S, has there been a history of review/improvement/testing to increase one's confidence in its credibility and acceptance? What types of analyses has it supported? What is the user community consensus regarding its utility and credibility? What are the sources of key data used? What are the major functional representations? Is there balance across functional representations?

TABLE 3-1 STRATEGIC INDICATORS

Age/maturity
Configuration management
Size of user group
Studies supported
Major changes and pace of change
Number of applications
Community consensus
Data sources
Functional representations
Functional balance and adaptability
Systems and integration assessment
Characterization of outputs
Model timing aspects
Stochastic vs deterministic

The group suggested that one could develop a list of functions common to most, with each representation possibly subdivided one or more times according to issues being addressed in an application.

The WG's consensus on units of V&V was "No, no, a thousand times no!" One notes that the status of a M/S is best represented by its pedigree and qualitative statements regarding its

V&V history, by tabular information and by "check-lists" of functionalities. Though one can add apples, oranges, grapes and other odd-sized items to arrive at a count of "things," to try to do something similar in this respect would be hopeless.

3. What factors should we use to determine whether to accept a M&S (or its results)?

The WG referred back to the template for the correct inputs. One should also review the M/S "strategic indicators."

4. a. What is a legacy model?

- b. Does a legacy M&S acquire any V&V credibility by its use and acceptance?**
- c. Do we V&V a legacy M&S any differently than any other M&S?**

There was agreement that many campaign/theater level M/S would be classed as legacy M/S because of their long use, high to moderate level of acceptability and low level of effort in the V&V area. Because of this long history most have achieved some credibility or face validity. Users know their limitations, and typically most problem areas are known within the analysis community. The group felt that all our V&V efforts on these would be less productive than systematically addressing critical functionalities over time, to include reverse engineering conceptual models against which validation assessments can be made.

WG 1 decided that additional things needed to be stated regarding V&V for campaign/theater level models. Because of the problems and challenges of validating this type of M/S, some part of the burden of V&V must be shifted to the application. "Reality checks" or examination of evolving results at the functional level in critical representations to the analysis at hand must be continuous. The need to fill in modeling "gaps" revealed through their

application in new areas further complicated the parallel process suggested above.

CHAPTER 4

WORKING GROUP 2

MISSION LEVEL

Co-chairs: Ms. Cheryl Black and Mr. John Riente

1. a. Can a template be developed to support accreditation?

The group concluded that a general set of guidelines can be developed for mission level models but there is no single standard for applying the template to all accreditations. For example, accreditation of a mission level model to support a training exercise would consider different factors and may assume different weights for specific factors than would accreditation for the same model to support operational planning.

1. b. What would such a template look like?

The group assumed that accreditation would be conducted by someone (action agent) other than the decision authority (accreditation official). The action agent is the individual, agency or ad hoc committee designated to conduct the accreditation. The template must include a charter (Terms of Reference/Tasking Document) issued by the decision authority to the action agent. The charter serves as a formal means of communication among the accreditation authority, accreditation action agent and the M/S proponent. By documenting the purpose of the application, objectives and specific concerns/issues for the intended use of the model, the charter establishes the scope and focus for the accreditation. The key measures of effectiveness, objectives of the application, features of the model of high interest and expectations of the decision authority would also be identified.

The accreditation action agent prepares the accreditation plan. The plan describes the approach to be taken to address accreditation official guidance, identifies responsibilities, resources required and provides a milestone schedule. The factors to be considered in the plan

are identified in the response to question 3.

The conduct of the accreditation assessment is addressed in the group's response to question 2. The WG members felt that the assessment should be accomplished at two key decision points:

- Early in the study planning process to help make model selection decision and to identify actions that would improve model credibility/utility for the application.
- At the end of the application to assess model modifications made during the course of the application.

The accreditation assessment, results and recommendations should be formally documented.

1. c. How should we go about developing such a template?

The WG decided that there is no "pass/fail" criteria for applying the template. The accreditation decision must consider the following: the criticality and risks of the application (e.g., battle operational plan is different than research investment decision) the scope of the application (e.g., battalion level mission or Joint Task Force operation) and the model choices (e.g., in some cases only one model may exist). It was agreed that the guidelines must be exceptionally broad applications and environments. Due to the exceptionally broad applications of M/S the general template would need to be tailored for applications within domains (e.g., training, RDA, operations, etc.) The template will evolve with use and its credibility will grow with experience.

2. a. How do we present the V&V status of a M&S?

Verification. The group concluded that verification of mission level models can be done. The process should concentrate on model functions/objects (and their interrelationships) which are critical to the particular application(s) of the model. Documentation is vital for the verification process, especially the functional description and analysts manuals which describe the model design, algorithms, assumptions, etc. If "good" documentation does not exist, verification becomes time consuming and expensive. The verification process should include scrutiny of the code, not just review of the documentation. A verification report should specifically address those functions/objects which are critical to the proposed use of the model. The report should identify critical functions verified and those not verified. The assessments should be qualitative and should identify the risks associated with not verifying parts of the model. The resources and milestones for correcting deficiencies should be identified.

Validation. The group determined that validation of mission level models is challenging and may never be fully accomplished. This is attributed to the fact that it is difficult to define "the real world" for Joint Task Force operations. Validation of mission level models should concentrate on the elements and interactions critical to the proposed application of the model. Critical elements/interactions include:

- Consistency with physics and engineering level representations.
- System and unit performance.
- Environment - Natural - terrain, weather, topography, etc.
- Created - communications, ECM, ECCM, radar, IR transmissions.
- Command/Control/Intel.

- Doctrine/CONOPS.
- Input data and assumptions.

A validation report should include a description of the proposed application of the model, definition of the "real world" for the application, and identification (list) of the elements/interactions critical for the application. The report should outline historical validation efforts to include evolution to the current model version and applicability to the current application. An assessment of the "holes" identified in previous validation efforts and a proposed methodology for filling the holes in the current validation should be included.

The group recommended that the community standardize V&V reporting format. This would facilitate subsequent validation efforts. The V&V documentation should be archived and that a central source for information regarding the location of V&V efforts should be established.

For mission level models Face Validation may be particularly useful. Training ranges, exercises and advanced warfighting experiments are increasingly being used in the context of DIS. The community should take advantage of these opportunities to validate models and simulations. Analysts/agencies tasked with model V&V should endeavor to make better use of data from man-in-the-loop simulators and results of comparable models which have been validated for similar applications. Models that have been used in the model-test-model mode or compared to recent military operations are especially useful in this role.

- Minority Opinion. One member of the work group felt strongly that if one can't understand the phenomenology of a "new" system or concept, then you shouldn't use digital models to study it and can't "validate" a model of it! The majority of the group believed that in this circumstance a model could be useful to improve understanding of the new system concept.

2. b. Are there "units" of V&V?

The group concluded that 'units' cannot be applied to quantify the extent of V&V. The emphasis of V&V should be to enhance model credibility. This necessitates focusing on the model application. The accreditation authority should be more concerned with impacts, implications and risks associated with using the model and its results than on some scale of V&V accomplished. The extent of V&V needed should depend on how the model results will be used and the resources/risk for the problem being investigated.

3. What factors should we use to determine whether to accept a M&S (or its results)?

As discussed in response to question 1c. there is no pass/fail criteria that can be used to determine acceptability. Some factors to be considered include:

- **V&V Status.** Define what elements/functions have been V&V'd and which have not.
- **Known limitations/constraints.** Availability of data, functions not represented; limits on the functions represented; hard constraints on geographic area, number of systems, etc.; aggregation level; hardware or software limitations.
- **Documentation.** Levels of documentation available should include at the minimum functional needs/description (functional decomposition), design objectives/baseline designs, user's manual and configuration management documentation. It should follow DoD guidelines for software life cycle management.
- **Clarity.** Should be able to explain results (cause and effect) and explain the results to system/object performance.
- **Sensitivity Analyses.** Model results behave in the expected way when the phenomenology or process is understood. Unexpected results call for more detailed examination to gain appropriate understanding.
- **Configuration Management.** Enforces good V&V; provides audit trail for modification and different versions of the model. Provides historical documentation of the uses of the model and formal procedures for documenting why certain modifications were made and an assessment of the success of the changes.
- **Functional Representation.** Identify mission needs and describe why mission level model was important for the decision. Explain why mission level model was essential for examining the decision criteria for the application. This helps assess the strengths and limitations in the context of the use of the model.
- **Risk Reduction.** Explain what was done to minimize known shortcomings of the model.
- **Alternatives Considered.** Explain why the model was selected.
- **Credential of V&V agent.**
- **Model Proponent/Developer.**
- **Proposed Use in the Decision Process.**
- **Historical Use.**
- **Affordability, Availability, Trained/Experienced Users.**
- **Risks.**
- **Previous Accreditations.**

4. a. What is a legacy model?

A legacy model is one that is continually improved over time, is configuration managed and has "broad" acceptance.

4. b. Does a legacy M&S acquire any V&V credibility by its use and acceptance?

Acceptance and use does contribute to a model's credibility, but this does not imply that the model should be exempt from the V&V process.

4. c. Do we V&V a legacy M&S any differently than any other M&S?

No. However, a legacy model's credibility will be enhanced with successful applications.

CHAPTER 5

WORKING GROUP 3

ENGAGEMENT LEVEL M&S

Co-chairs: Mr. Robert Hartling and Mr. Mark Ralston WG 3A
Co-chairs: Dr. Paul Muessig and LCDR Michael Borowski WG 3B

The summary of the results of the Engagement Level M&S WG at the MORS SIMVAL '94 Workshop is reported here. Due to the high level of interest in the Engagement Level WG, two subgroups (3A and 3B) were formed. The Chair of WG 3A was Bob Hartling of the Warfare Requirements and Analysis Division of the Chief of Naval Operations; the Co-Chair was Mark Ralston of the Army Materiel Systems Analysis Activity (AMSAA). The Chair of WG 3B was Dr. Paul Muessig of the Naval Air Warfare Center, China Lake; the Co-Chair was LCDR Mike Borowski of the Navy's Operational Test and Evaluation Force, Norfolk. In practice, WGs 3A and 3B stayed together, and the WG results were compiled into this summary, reflecting the consensus of about 40 M&S professionals.

The summary is divided into three sections. The first section describes the Engagement Level WG approach to answering the conference questions. The second section describes the WG's detailed answers to these questions developed over the course of the Workshop. The last section summarizes future directions implied by the workshop results. Many of these were taken up for action at a SAG meeting held at the close of the Workshop.

The WG session began with a series of case studies in accreditation. The case studies were included to communicate lessons learned from actual experience, and to set the stage for detailed discussions of the workshop questions. Mark Ralston discussed AMSAA's efforts at accrediting EVADE. Van Underwood of JHU/APL discussed the simulation management process required to accredit a Tomahawk M&S. Paul Muessig reviewed the results of an accreditation requirements study conducted by

the SMART (Susceptibility Model Assessment and Range Test) Project.

The session proceeded with a logical analysis of the conference questions given by Paul Muessig. The aim was to delimit the range of possible answers to the Workshop questions by analyzing the questions in themselves implied in the ability to answer them. The analysis demonstrated that the Workshop questions implied the necessity of a set of standard (i.e., well-defined and articulated) V&V process elements and a standard way to report results. This conclusion resonated with both the case studies and the accreditation requirements study conducted by SMART.

The detailed discussions focused on each conference question in turn, evaluating the applicability of individual lessons learned and on developing a consensus about the necessity of standard V&V process elements and products. Each question was then reviewed in detail near the end of the Workshop, and the following summaries were produced.

1. a. Can a template be developed to support accreditation?

Based on the case study lessons learned and intense discussion, WG3 concluded that an accreditation template could and should be developed. All agreed that differing requirements for template content based on modeling level or application did not preclude the possibility of developing one.

1. b. What would such a template look like?

WG3 concluded that an accreditation template would most likely consist of a core set of standardized (i.e., well-defined, articulated and accepted) V&V process elements and products. Elements from this list would be chosen to support individual accreditation efforts based on application requirements and clearly defined M&S acceptance criteria based on these requirements.

1. c. How should we go about developing such a template?

WG3 determined that the best way to develop an accreditation template would be to begin with the core set of V&V elements developed by SMART (from its accreditation requirements study) and build from there based on application types, modeling level and any other factors determined to be pertinent. The medium for development of such templates would be small workshops with limited objectives sponsored by MORS. The initial templates developed would then be distributed to the wider community for comment and consensus development.

One very important issue arose during discussion of the above questions: Should a minimum standard of V&V be specified for all M&S? Put another way, is there a minimum amount of V&V information that should be developed for a model before it is given serious consideration for use in an application? The group was strongly divided on this issue. The general consensus (about 25 of 40) held that minimum V&V standards would be counterproductive since any minimum standard would quickly become the de facto standard. ("If the minimum weren't good enough, it wouldn't be specified as the minimum.") A strong minority opinion held, however, that an amount of V&V sufficient to characterize a model (analogous to nutrition labels on food products) would represent a useful minimum before rational use of a model could be justified.

2. a. How do we present the V&V status of a M&S?

WG3 determined that the answer to this question depended on the target audience. For an accreditation authority, it was felt that reports of progress to date on a pre-approved accreditation plan would suffice, as opposed to detailed summaries of technical material. However, to the wider M&S community, it was felt that a summary of progress and results for each standard V&V element of the template developed under question 1c. would provide an important snapshot of a model's V&V status and history. Although no one suggested that this information alone was sufficient for any accreditation, it was a consensus among the group that there was a dire need for a standardized reporting format for V&V results for each element of the template. It was further determined that a need exists for a database of previous VV&A efforts and results so as to minimize duplication of effort and reduce the costs of accreditation. It was noted that the SMART Project has developed both standard reporting formats for many V&V elements and an Accreditation Support Database that will shortly be administered through SURVIAC for survivability M&S. These inputs would prove especially useful as a starting point in template development under the previous question.

2. b. Are there "units" of V&V?

It was the consensus of WG3 that there are no units for V&V per se. V&V requirements are application dependent, and as such there is no "one size fits all" way to quantify the V&V status of a model. It was further agreed that it would be misleading to develop and promulgate application — independent V&V "metrics" for general use. However, for M&S community at large it was felt that a V&V database could provide a central mechanism for the accumulation of objective V&V evidence that could support accreditation decisions.

3. What factors should we use to determine whether to accept a M&S (or its results)?

WG3 had a hard time with this question. On the surface, it appeared either redundant with Question 2, or simply too ambiguously stated to answer in any unambiguous way. The group finally decided to interpret the question as a means of defining a filtering process for model selection. In this context, all the items listed in the Workshop handouts for this question (e.g., V&V status, usage history, cost of application, etc.) were deemed to be of value in model selection prior to use for a specific application. The group determined that several items were missing from the list that deserved mention:

- *Data Availability.* "The data are the model," was the most common refrain. If a model's data sets are sparse or undocumented, its utility is similarly limited.
- *Configuration Management (C/M).* If a model is not well managed, its results may not be trustworthy, V&V notwithstanding. C/M maintains the "shelf life" of V&V. Poor C/M practice leads to needless squandering and spoilage of hard-won V&V gains.
- *Documentation.* A poorly documented model cannot be verified or validated without major expense. The quality of the documentation also affects the cost of model use, in that learning curves become steeper and training expenses rise.
- *Applicability.* Some characterization of the model's application domain was felt to be an important factor in model selection. "If all you have is a hammer, everything starts to look like a nail." The frequency to improper use of models could be reduced with a concise statement of application domain and utility.
- *Community Acceptance.* Similar to the answer at the first bullet of question 4b, WG3 felt that community acceptance

implied a de facto "face validation" of the model, especially if it is also well managed.

The group added that a V&V Library capturing this information would be especially useful as an aid to model selection for particular applications. It was noted that V&V is currently not a major M&S selection criterion because of the paucity of V&V information and V&V information sources. A V&V Library would thus not only aid accreditation once a model had been selected for use, but would also aid model selection and prioritization of V&V objectives in support of accreditation.

4. a. What is a legacy model?

There were many opinions on what factors a minimum definition of "legacy" model would include. The group moved on to answer the following questions, and discovered that none of the answers depended on an answer to this question. We concluded, therefore, that since the term "legacy" had no bearing on V&V requirements or process elements, it was not a particularly useful descriptive term. Reference was made to the definition of "legacy" in AFI 16-1001 (the Air Force draft M&S management policy), where the key difference between legacy and other simulations was lack of coding and documentation standards. It was observed, however, that neither of these factors had a bearing on current usage or acceptance of legacy M&S. Again, the group concluded that "legacy" was not a term useful in answering the central Workshop question, "How much V&V is enough?"

4. b. Does a legacy M&S acquire any V&V credibility by its use and acceptance?

WG3 determined that any model gains credibility through use and acceptance. In fact, it was noted that legacy M&S may have more credibility in this regard than new M&S developments, despite the latter's adherence to coding and documentation standards. Dips in the acid bath of reality were deemed to be more important in assaying M&S than mere

adherence to standards, at least early in a model's usage history. Again, the term "legacy" added no new V&V requirements or rethinking of basic Workshop issues.

4. c. Do we V&V a legacy M&S any differently than any other M&S?

WG3 determined that there would be no difference in a notional accreditation template between legacy and other M&S. Although it was agreed that verification of legacy models did involve a reverse engineering of the conceptual model and design specification that would not be required of new model developments, validation and accreditation requirements would be the same. We viewed the legacy model accreditation vice new model accreditation as a non-issue.

CHAPTER 6

WORKING GROUP 4A

Advanced Distributed Simulation/Distributed Interactive Simulation (ADS/DIS)

Co-chairs: Dr. Julian Palmore and Mr. Robert Eberth

Due to the large number of participants electing to work in the ADS/DIS working groups, the Group was subdivided into two independent subgroups 4A and 4B.

The Advanced Distributed Simulation/Distributed Interactive Simulation (ADS/DIS) environment differs from other environments with respect to VV&A. Our WG explored VV&A from this perspective.

- DIS exercises are asynchronous; there is no central time or time check.
- DIS experiments are non-repeatable, largely as a result of the asynchronicity.

A DIS exercise or experiment consists of live, constructive and virtual entities and cells, collections of entities, networked together through the use of highly structured standardized communication protocols.

To be DIS-compliant, an entity or cell must adhere only to the applicable Protocol Data Unit (PDU) standards. DIS-compliance does not imply any level of VV&A has been performed.

Moreover, the entities in an exercise may be at differing levels of both logical and presentational granularity, and at differing levels of fidelity and validity.

Thus, VV&A must be addressed at two levels in the DIS environment;

- VV&A of the entities and cells
- VV&A of the exercises

Our WG started with the question, "How should

we approach VV&A of legacy models?" We used that approach and reported it that way because our deliberations on the legacy models led us in particularly productive directions with respect to the remaining questions.

4. a. What is a legacy model?

We reached a consensus definition and other definitions of interest.

- Consensus Definition:
 - » Model developed in the past that is still available and was not implemented using current standards.
- Minority Definitions:
 - » DA PAM 5-11: Historically, the M&S of choice for a specific application.
 - » OSD: There are only two types: Existing or New.

It took well over an hour to come to a consensus definition for a "Legacy Model." While this definition is the consensus of the WG, both of the minority definitions had numerous strong adherents. The key point is that the consensus definition does not imply any favored VV&A status on a model for DIS applications simply because it may be "favored" historically for one or more specific applications.

4. b. Does a legacy M&S acquire any V&V credibility by its use and acceptance?

Yes, but "credibility" needs to be viewed in balance with all other accreditation elements within the DIS context.

Certainly, "use and acceptance" imply that many persons, including a number of domain experts, have looked at the model and found it acceptable for the purpose at hand. However, such use and acceptance is only a limited and unstructured form of "face validation," a VV&A technique of problematic rigor and power to begin with. Thus, "credibility by use and acceptance," in itself, should not be sufficient for accreditation. This is true particularly in the DIS context, where each model may be only a single entity or cell and may be interacting with other DIS compliant entities or cells for which it has been modified. The "other accreditation elements" will be seen below.

4. c. Do we V&V a legacy M&S any differently than any other M&S?

For all models, legacy and new, an accreditation plan is needed that addresses the model's use in a specific DIS exercise.

For analytic applications, the questions to be investigated should be set up as hypotheses to be tested and the DIS exercise treated as experiments that test the hypotheses. This is presented below as an Experimentalist Framework for Distributed Interactive Simulation.

The exercise itself should be accredited through the use of conceptual models and metamodels and techniques to measure the degree of compatibility and consistency between entities.

EXPERIMENTALIST FRAMEWORK FOR ADS/DIS SIMULATION EXERCISES[†]

1. State the problem.
2. Formulate hypotheses within a conceptual model.
3. Devise experimental techniques.
4. Examine possible outcomes with which to evaluate the experimental techniques.
5. Consider possible results and statistical procedures to validate statistical analyses.

6. Perform the experiments as DIS exercises.
7. Draw conclusions by analyzing the experimental results.
8. Evaluate the distributed interactive simulation experiment.

While the question is cast in the context of Legacy Models, the answer is cast in a broader context. This is the heart of the matter: the need to introduce scientific method into the VV&A process. Here, it's tailored to the DIS environment; the concept is applicable across the board.

Breakthroughs in conceptual thinking and in methodology now make it appear realistic to quantify critical aspects of "validity." Specifically, the "Experimentalist Framework" shows a conceptualization of distributed interactive simulation exercises that resulted from a challenge to the Military Operations Research community by Mr. Walt Hollis, FS the DUSA for Operations Research, to find ways to use DIS exercises for analysis, in addition to training. Its point is that the only way to validly employ DIS exercises for analysis is to first state the analytical objectives as hypotheses to be tested, then use the exercises as carefully structured scientific tests of the hypotheses. The same concept can be applied to hypotheses regarding the validity of individual entities and cells, and to the overall exercise itself.

[†] J. Palmore, A V&V Framework for Analysis in Distributed Interactive Simulations, in Object Oriented Simulation Conference (OOS'94), Proceedings of the 1994 Western Multiconference, Society for Computer Simulation, January 1994, pp 49-54.

Other work reported at the 10th DIS Workshop included the potential use of Fast Fourier Transforms to quantify the consistency among entities, and of Colored Petri Nets, which can be used to produce quantitative measures of merit, to build metamodels of DIS exercises prior to going to the time and expense of actually putting the

exercises together.

1. a. Can a template be developed to support accreditation?

Yes. We found the first part of the question rather straightforward to answer.

1. b. What would such a template look like?

The template should be based on the DIS Workshop VV&A Process as modified by:

- DA PAM 5-11, plus interfaces, Tools, use of SIMTAX and interfaces in M&S description, Verification of Architecture, Data V&V, Evaluation Criteria MOE's and M&S Purpose.
- DMSO IPL#2 Project for the U.S. Army V&V of Models and Simulations.

We believe that, at least for DIS accreditations, the VV&A Process "template" developed by Robert O. Lewis and the standing DIS VV&A WG provides the best starting point. It is shown in Figure 7-2. The DIS Workshop VV&A Process, however, is not sufficient. It needs to be modified to include additional steps and information from several sources.

- Department of the Army Pamphlet 5-11 contains a sample Accreditation Plan format that provides for other extremely useful data to lead to an accreditation decision.
- Similarly, the Simulation Taxonomy (SIMTAX) developed by MORS and incorporated in the J-8 catalog of models provides additional extremely useful data on the accreditation template.

1. c. How should we go about developing such a template?

We should modify existing prototypes as appropriate.

This is answered, in part, by a template based on

the VV&A Process. There should not be only one template; the templates should be tailored to the individual accreditation decision environment. Data elements should be included in all templates. In particular, the data captured by using SIMTAX in every template goes a long way toward enabling useful comparisons of model attributes.

2. a. How do we present the V&V status of a M&S?

Presenting the V&V status is done by:

- Break out Verification from Validation; report on each separately.
- For Verification, use the existing, proven methods.
- For Validation, "by another mechanism."
- The "other mechanism."
- SIMVAL II: Validation: "is the degree to which a model is an accurate representation of the real world."
- Establish and apply MOEs and MOPs from outset.
- Output validation: "extent to which the output."

This represents the significant and salient features of the real world, comparison of real world data with output of the model, coefficients of correlation and confidence levels.

- Structural validation: "extent to which input data and the conceptual model represent the significant and salient features," data V&V, peer review, etc.

We suggest reporting the status of the two Vs separately. Verification is a speciality unto itself. There are a host of useful tools to perform it, starting with requirements traceability tools. We

suggest strongly is including in this area the results of the peer review recommended previously. As discussed in the SIMVAL II report, many of the algorithm checks, reverse engineering and other techniques common to peer review fall generally into the category of "logical verification."

The mechanism we suggest for reporting the status of validation is SIMVAL II, specifically, by developing and applying statistical data, validation and logical or output validation definitions laid out by the SIMVAL II Proceedings. Peer review results pertaining to the structural validity of the model appear here also.

3. What factors should we use to determine whether to accept a M&S (or its results)?

These are DIS VV&A Process items plus:

- Cost of additional V&V prior to the point of decision.
- Time remaining prior to the point of decision.
- Risk of failure and impact of failure.
- Potential costs of incorrect decisions (Type I/Type II errors).
- Results of peer review of the conceptual models.
- Other credibility related information.

It cannot be overemphasized that accreditation is a management decision regarding the use of a particular model in a particular application. Moreover, it should be for use with a particular data set that has itself been verified, validated and certified. As with any management decision, the information is rarely complete, rarely absolute and always constrained by time and cost. Thus, the additional factors that should be addressed throughout the accreditation process are:

- Cost of more complete and better information.
- Time remaining to collect more information.
- The risks and costs of making the wrong decision.
- Accrediting a model for use when it is, in fact, invalid for the application.
- Refusing accreditation for a model when it is, in fact, valid for the application.
- All credibility related data.

With regard to "credibility related data" possibly the single most powerful tool for VV&A is peer review of the conceptual model. Coding and computerization are only the implementation of the conceptual model. No matter how sophisticated the coding and computerization techniques, they can at best conserve the inherent value of the conceptual model. Thus, peer review of the conceptual model can offer a relatively fast and effective "credibility check" in the accreditation process. Peer review, by definition, is independent of the developer and his/her organization.

CONCLUSIONS

The WG drew several conclusions.

- There is a need for the use of the scientific method and sound engineering principles for designing distributed interactive simulation exercises as experiments for analysis.
- Peer review of M/S should be done
- It is important to use MOE's and MOP's in verification and validation of DIS exercises

CHAPTER 7

WORKING GROUP 4B

Advanced Distributed Simulation/Distributed Interactive Simulation (ADS/DIS)

Co-chairs: William Dunn and Mr. Rob Wright

1. a. Can a template be developed to support accreditation?

We first addressed the question "Can a template be developed to support an accreditation?" We agreed that the answer is yes, however there should be a family of templates tailored to the "logical" uses of DIS applications. A typology of logical uses of DIS is shown in Figure 7-1. It was created under the assumption that one could define general classes of logical use such that:

- The role of DIS in any reasonable use would appear in some class.
- Validity criteria could be identified for each class.

The typology first distinguishes between using DIS as an analytic aid and stimulus.

Assessments of the validity of a DIS configuration must be based upon determination that individual participants gained the desired experience. The means for doing this varies with the nature of the experience that is desired. In training for standardized proficiencies where there is strong transferability, completely objective means for testing the participants exist. An example is tank gunnery training to test individual or crew proficiency. When training for standardized proficiencies that are only weakly transferable, objective criteria exists, but non-objective means are required to assess whether they will transfer to the real world experience. Examples include applications at the battalion level using Army Training and Evaluation Program Mission Training Plans for evaluation or a unit's mission rehearsal. For those

uses where there are no standards, assessments of credibility will require subjective judgement on the part of appropriate experts. A joint staff training exercise is an example of a use requiring subjective validation.

Assessing the validity of a DIS configuration as an analytic aid depends upon the degree of predictivity required of the system for that use. Non-predictive uses require little predictive power from DIS. Hence, for these uses credibility depends on the verification that the system performs the logical functions expected of it (be they bookkeeping or logical implications). An example of bookkeeping is a data collection effort of hardware reliability. A logic tracing example may contrast a DIS scenario to previous lessons learned. Strongly predictive uses treat system outputs as detailed predictions of expected real world outcomes. For these uses credibility requires statistically rigorous model validation and sufficient test cases to provide significance in the results. Examples are uses of doctrine validation and weather effects for operations other than war. Between these extremes exists a large class of uses that require weak predictivity. For these uses, credibility depends not only on system characteristics, but on the details of the intended analytic argument and associated research strategy. Weak predictivity examples are test and evaluation analysis using simulation to supplement real world results (a fortiori) while analysis of a commander's operations plan reflects an example of plausible outcomes.

In the past, the credibility of simulation-based applications has been assessed through a process of VV&A. While all three of these activities are clearly needed in the context of DIS, their relative importance varies significantly across the

categories of logical use. For non-predictive analysis, credibility can be established primarily by means of verification. For strongly predictive analysis and uses that have strongly transferable standardized proficiencies, their existence means to validate the system or training protocol, so that this validation suffices to establish credible use. For analyses and uses that are either non-standardized or weakly transferable, subjective judgement is unavoidable in assessing credibility. Consequently, it is for these uses that a formalized process of accreditation is most needed.

Early in the planning phase, the template development process should ensure application requirements will be met. The first step is for the DIS designer to review and analyze the purpose and objectives of the DIS application. The role DIS is to play in meeting these objectives should be defined and the initial allocation of the implementation to the applicable live, virtual or constructive subset should be decided. This is shown as Block 1 "Plan Exercise and Develop Requirements" in the VV&A Process Model, Figure 7-2. After considering the potential candidates in the various repositories (e.g., M&S, data, objects) reflected as output from Block 2 "Compliance Standards Verification DIS Repository(ies)", a preliminary design can be developed into a conceptual model. Development, verification and validation of the conceptual model prior to construction of the actual application confederation, reflected in Blocks 3 and 4, are discussed in the appendix to this subgroup report.

The template for each use begins by tailoring the library of elements for a stand alone M&S. However, the DIS template must go further to investigate the DIS-related aspects e.g., fidelity evaluation, network interfacing and performance, dead reckoning implementation, resolution of terrain and common data bases and aggregation issues as reflected in the VV&A Process Model. The fleshing out of this process model by the M&S community is ongoing at the present time and will drive template development.

One of the issues to be fleshed out is data verification, validation and certification (VV&C). VV&C of data is critical to the entire DIS VV&A process because data is the foundation on which the entire DIS application is based. Data must be collected from authoritative sources and certified data bases whenever possible. An authoritative source is an organization which is either:

- Designated and recognized as the producer of best-estimate data values.
- It is designated to conduct producer VV&C activities for one or more categories of data.

Certified data bases are sets of data which have been verified, validated and approved (certified) for specific applications. The authoritative sources should construct their own internal VV&C of the data before providing the product to the DIS designer.

The VV&A agents of the DIS designer (i.e., the user) must assess the data sources and modifications to the data to meet application unique requirements. In some cases the requisite data may not be available from a recognized authoritative source or may not be acceptable for the DIS application. In this situation, the user has three options: use comparable or surrogate data from an unapproved source, delete the algorithms or simulations requiring the data, or create/obtain the data and conduct a complete VV&C. The user must determine that any "unapproved source" data complies with applicable data standards. If not, then a decision must be made to either modify the data to make it conform or accept "as is" and accept the risk associated. Domain analysis, data activity modeling, data element modeling, and data standardization are all very important tools available to assist the user in the VV&C/VV&A process. Depending on the decisions made at each stage, the user may need to use some or all of these tools to ensure that the data is suitably evaluated to pass the VV&C tests necessary to reach an acceptable level of risk yet not yield an adversarial impact on cost, schedule and performance.

VV&A template development must include provisions for the VV&C of data. Each individual M&S will have previously approved data or it will undergo the VV&C/VV&A steps necessary to use the data before being accepted as part of the DIS. V&V agents of the DIS will conduct data for VV&C as part of the VV&A process to determine that:

- The data has been properly verified and validated for use with each of the individual M&S.
- The each individual M&S will produce results in the confederation as occurred independently (i.e., that the participation in the DIS will not affect the validity of the individual M&S).

2. a. How do we present the V&V status of a M&S?

Our subgroup defined this to mean "How do we present the V&V status to an accreditor?" To answer this question, we began at the planning stage. When an application is planned, the purpose and objectives should be clearly defined and the processes determined which will answer these objectives. The V&V status for the DIS application should be geared toward meeting the objectives. We recommend verification status and validation status be reported separately. The status is qualitative in nature and addresses whether the objectives have been met, identifies any limitations, and most importantly assesses risk inherent in selecting that set of candidates. Recommendations to reduce, eliminate or work around the risk should be provided to the accreditor. It is essential that these V&V information data be captured and placed in one of the DIS repositories for future reference.

Appendix G in Department of Army Pamphlet 5-11 "Verification, Validation, and Accreditation of Army M&S" is a good example of the status reporting elements for V&V. These are summarized as:

Executive Summary. This stand-alone section identifies critical issues, trends and/or sensitivities. It should present the results of a reasonable, systematic examination of the V&V process. It gives an objective picture of the strengths, weaknesses, limitations and risk in terms of the intended use. A specific statement regarding the confidence and credibility associated with the M&S in the context of its intended application is made in this section.

Overview of the V&V Planning:

- Identification of differences from V&V planned.
- Personnel performing the VV&A.
- Description of the verification process and/or tests.
- Logic Verification Results.
- Code Verification Results.
- Unresolved Issues.
- Description of the Validation process and/or tests.
- Evaluation Criteria.
- Structural Validation Results.
- Output Validation Results.
- Unresolved Issues.
- Ongoing or Follow-on V&V activities.
- References, attachments and appendices.

Although we were emphatic that a status is qualitative, an interesting sidelight of our subgroup identified the "Strong transferability" and "Strongly predictive" legs of the typology diagram, Figure 7-1, as possibly capable of portraying a quantitative status. As an example, a

tank gunnery application could show percentage of participants who tend to pass proficiency using this DIS application.

3. What factors should we use to determine whether to accept a M&S (or its results)?

The next question is "What factors should we use to determine whether to accept a M&S (or its results)?" The important factors are V&V status, risk assessment, schedule and programmatic considerations which may affect availability for the application, cost, ease of use and adaptability.

V&V status is important since this gives the accreditor the confidence to accept or reject the DIS application for its intended use. The V&V status provides the accreditor information as to how thoroughly and rigorously the application was reviewed. This knowledge aids in determining that the application has been sufficiently reviewed by qualified subject matter experts thus providing confidence to the accreditor and reducing risk.

Risk assessment evaluates and measures the amount of risk quantitatively in terms of cost, schedule and performance. Risk factors can be selectively considered to accurately reflect application unique requirements or accreditation unique criteria. Similarly, risk avoidance or risk reduction initiatives can also be addressed in the risk assessment. As with V&V status, a well documented and accurately structured risk assessment can assist the accreditor by identifying high risk concerns before the application progresses to the final decision point.

Schedule implications must be presented at every stage of the decision process since each decision alternative impacts schedule in terms of cost, performance or availability.

Programmatic considerations include management, user (e.g., training) and other issues (e.g., human factors, safety). Although any one of these issues in and of itself may not be a "show stopper", the aggregation of these issues may increase risk of failure and have an ultimately

adverse impact on cost, schedule or performance. Programmatic issues must be addressed in the V&V status.

Less important was the source of the model and its historical use. This latter element should be qualified in that our assumption was that individual M&S were in the repository (ies) and have a Service/Agency VV&A history. If the M&S was used in a stand alone mode, its history is significantly less important than if it has been used in previous DIS applications.

4. a. What is a legacy model?

The last question concerned "legacy" models. The subgroup assumed that "legacy" refers to individual M&S in the repository (ies) since we opined that for most applications, it will be rare for an entire DIS confederation network to be reused in the exact same configuration. "legacy model" is defined in the Defense Systems Management College 'Systems Acquisition Manager's Guide for the Use of M&S' as: "A model developed in the past which is still in use that was not implemented using today's standards (e.g., software, communication, DIS, ALSP, etc.) Some legacy models have been modified with interfaces to some of the current standards extending their usefulness and interoperability with newer, standards based models."

We determined that individual legacy M&S was not an issue for DIS applications since the basic standards to be in the repository required each M&S to have a Service/Agency VV&A history and meet DIS-compliance testing. Thus, they are to receive VV&A in the same manner as other M&S. Finally, any M&S (whether considered as an individual legacy M&S or otherwise) will acquire credibility by use in a DIS environment assuming it meets DIS standards just as its usage would in a stand alone case.

References

1. *Credible Uses of DIS (Draft Report)*, Jim Dewar and Steve Banks, RAND Corporation, 1994
2. *Methodology Handbook for VV&A of DIS (Draft)*, Quality Research Corporation et al (DMSO-funded project), September 1994
3. *Department of Army Pamphlet 5-11, VV&A of Army M&S*, Headquarters, Department of the Army, 15 October 1993
4. *Systems Acquisition Manager's Guide for the Use of Models and Simulations*, COL Piplani et al, Defense Systems Management College, September 1994
5. Report on the Simulation of Processes (modified), Gary Q. Coe, ANSER for ASD(C3I), pp C-4, C-7, 15 April 1993

CHAPTER 8

WORKSHOP SUMMARY

The findings of the SIMVAL 1994 working groups are summarized in this chapter. The summary is organized by each key question.

1. ACCREDITATION TEMPLATE

1. a. Can a template be developed to support an accreditation?

All working groups said Yes. Most indicated that there should be a family of templates based on M&S level/application type/use. The concern was that one template would not fit all M&S uses. A super-template' might be created, but it would have to be tailored for each accreditation by application type.

1. b. What would such a template look like?

The following is a composite from all working groups of the items to be included in the template.

A. Application Description

1. Purpose of application
2. Objectives
3. Specific issues/concerns
4. Application risk/importance
5. Time requirement for accreditation
6. Resource constraints

B. Accreditation Basics

1. M&S Description (Title, M&S scope/overview, version)
2. M&S Proponent (Reputation/Experience)
3. Proposed use in Decision Process (Integration with other methods/data)
4. Key Functional Representations
5. V&V Status (See response to question 2.a)
 - Includes Credentials of V&V agents

6. Sensitivity Analyses Performed
7. Known Limitations/Constraints
 - Includes Degree of Clarity (Cause and Effect)
8. Configuration Management/Control
9. Documentation Available
10. Data
 - a. Sources
 - b. Verification Status
 - c. Validation Status
 - d. Certification
 - e. Uncertainty
11. Affordability
12. Availability (of M&S and Trained, Experienced Users)
13. Risk Reduction Actions
14. Alternatives considered
15. Historical Use, Acceptance, Known Applications (including any specific DIS use)
16. Previous Accreditation History (including any specific DIS use)

C. Assessment Approach

1. Acceptance criteria (by key function)
2. Priority Sequence of key functions for V&V (useful if under time or resource constraints)
3. Methodology for Meeting Criteria
 - a. Verification Plan
 - b. Validation Plan
 - c. DIS Considerations (if a Distributed Interactive SImulation)
 - See DIS Workshop VV&A Process
 - d. Impact on application of M&S functions not verified.
 - e. Impact on application of M&S functions not validated.

D. Recommendations/Options

1. Actions to be Taken (if any)
2. Caveats, by Functional Representation

E. Decision

Other models or information sources for the templates suggested were the SMART (Susceptibility Model Assessment and Range Test) set, DIS Workshop VV&A Process, DA PAM 5-11, SIMTAX, DMSO IPL#2, and Paul Davis/Rand Model.

1. c. How should we go about developing such a template?

The following approach came from the working groups and was the consensus approach of the Co-chairs/SAG meeting held immediately after the Workshop ended.

The output of the SIMVAL 1994 Workshop will be used as the basis for developing a draft set of templates. The result would be a set of guidelines for specific applications and M&S types. These draft guidelines will be put on an electronic bulletin board now being implemented by MORS. This would allow review and comments from across the community on the form/contents of these templates. When the draft has been reviewed (and comments die down), the final set will be published.

2. V & V STATUS

2. a. How do we present the V&V status of a M&S?

The working groups generally agreed that V&V status should be reported separately.

A. Strategic Indicators

1. Age/maturity
2. Level of Configuration Management
3. Size of User Group
4. Major versions/Pace of change
5. Number of applications/studies supported
6. Data Sources
7. Functional Balance
8. Functional Adaptability

B. Verification Status

1. Key Functions/Elements/Interactions List
2. By key function/element/interaction
 - a. Verification method used
 - b. M&S version to which applied
 - Include linkage to current version
 - c. Date of application
 - d. Verification agent
 - e. Verification report reference
 - f. Verification results (quantitative statements)
 - g. Verification conclusions (qualitative statements)

C. Validation Status

1. Key Functions/Elements/Interactions List
2. By key function/element/interaction,
 - a. Validation method used
 - b. M&S version to which applied
 - Include linkage to current version
 - c. Date of application
 - d. Validation agent
 - e. Validation report reference
 - f. Validation results (quantitative statements)
 - g. Validation conclusions (qualitative statements)

D. Limitations/Risks

2. b. Are there "units" for V&V?

All the working groups agreed there were no "units" for V&V.

3. ACCREDITATION FACTORS

3. What factors should we use to determine whether to accept a M&S (or its results)?

The working groups indicated the factors used in the accreditation template were appropriate (See response to question 1B. above).

4. LEGACY M&S

4. a. What is a legacy model?

The working groups varied in their response to this question.

- "[A legacy M&S] has a long history of use; high/moderate level of acceptability; negligible V&V."
- "A legacy model is continually improved over time, configuration managed, and has broad acceptance."
- "A model developed in the past that is still available and that was not implemented using current standards."
- "Assume legacy' refers to individual M&S in the DIS repository. Non-issue for DIS environment since M&S must meet basic DIS standards to be in the repository."
- "'Legacy' is not a useful term."

4. b. Does a "legacy" M&S acquire any V&V credibility by its use and acceptance?

The working groups basically agreed credibility accrued to a M&S by use (for a legacy' or any other M&S), but should go through the same processes for VV&A as any other M&S. It should have a larger database of historical use and VV&A from which to draw, thereby making an accreditation decision easier or quicker.

GENERAL

Most of the working groups mentioned that the existence of repositories of M&S information and make VV&A less expensive. It would also eliminate redundant V&V efforts. The recommendation was not necessarily for a single repository, but at least for common standards for all DoD repositories so that information is compatible and consistent.

CHAPTER 9

WHERE DO WE GO FROM HERE?

There was a SIMVAL SAG Meeting held immediately following the SIMVAL '94 Workshop to determine where/how the SIMVAL series should proceed. The guidance provided was:

- A. Use the WG findings to develop a set of draft accreditation templates and guidelines for how much V&V is needed to permit a credible accreditation decision. The guidelines will consider application type, application importance/risk and M&S type. The templates and guidelines will be put on the MORS electronic bulletin board to provide MORS members the opportunity to review, comment and suggest changes. At the point where there appears to be general community consensus, they will be formally published.
- B. It was agreed that no additional SIMVAL workshops would be held until the community has had time to use the VV&A guidelines developed by the SIMVAL series. At some future date, another workshop to discuss case studies of the guidelines would be beneficial.
- C. The SIMVAL series should sponsor an activity to consider simulation validation in commercial industry. There are a number of commercial systems (e.g., aircraft, trucks) similar to military systems, that are modeled by industry for development and other purposes.

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ADS	Advanced Distributed Simulation
AFI	Air Force Instruction
ALSP	Aggregate Level Simulation Protocol
AMSAA	Army Materiel and Systems Analysis Activity
ASD	Assistant Secretary of Defense
BMDO	Ballistic Missile Defense Organization
C/M	Configuration Management
DIS	Distributed Interactive Simulation
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DUSA(OR)	Deputy Under Secretary of the Army (Operations Research)
ECM	Electronic Countermeasures
ECCM	Electronic Counter-Countermeasures
GAO	Government Accounting Office
IDA	Institute for Defense Analyses
IPL	Integrated Priority List
IR	Infrared
IV & V	Independent Verification and Validation
JHU/APL	Johns Hopkins University/Applied Physics Laboratory
M&S	Models and Simulations
MOE	Measure of Effectiveness
MOP	Measure of Performance
MORS	Military Operations Research Society
NADC	Naval Air Development Center
OSD	Office of the Secretary of Defense
PAM	Pamphlet
PDU	Protocol Data Unit (DIS)
SAG	Senior Advisory Group
SIMTAX	Simulation Taxonomy
SIMVAL	Simulation Validation
SURVIAC	Surviveability Integrated Activity Center
V&V	Verification and Validation
VV&A	Verification, Validation and Accreditation

SIMVAL 94' WORKSHOP AGENDA

Draft—August 3, 1994

Tuesday, September 27

- 1600 Early registration Begins (*Lobby of Fred Harvey Hotel*)
1800 End Early registration

Wednesday, September 28

- 0700 Registration/Continental Breakfast (*BDM Sandia Vista Conference Center*)
Cochair's Breakfast Meeting and Orientation (*BDM SVCC*)
0800 Welcome by MORS Representative
0810 Introduction to Workshop (*Williams/Sikora*)
Background of SIMVAL Series
Overview of SIMVAL 94' Workshop
- Purpose
- Agenda/Key Players
- Breakout rooms
- Products
Administrative Announcements
0830 Plenary Session 1
Air Force Overview of VV&A—Process, Issues and Concerns
Air Force Exemplary Case Study/Paper
1000 Break
1015 Army Overview of VV&A—Process, Issues and Concerns
Army Exemplary Case Study/Paper
1145 Lunch
1300 Plenary Session 2
Navy Overview of VV&A—Process, Issues and Concerns
Navy Exemplary Case Study/Paper
1430 Break
1445 Marine Corps Overview of VV&A—Process, Issues and Concerns
1515 OSD Overview of VV&A—Process, Issues and Concerns (*Sanders*)
1545 GAO Overview of VV&A—Process, Issues and Concerns

Wednesday, September 28 (cont.)

- 1615 End Plenary Session II
Overview of Working Group Expectations
- 1630 Working Group Introductions/Orientations
Break-up into Working Groups—(Assigned Working Group Areas)
- 1700 End Working Group Introductions/Orientations
Begin Mixer (*Lobby of Sandia Vista Conference Center*)
- 1830 End Mixer

Thursday, September 29

- 0730 Continental Breakfast (*Lobby of Sandia Vista and Randolph Conference Ctr*)
- 0800 Working Group Sessions (*Breakout Rooms*)
- 1200 Lunch (*Lobby of Sandia Vista Conference Center*)
- 1300 Working Group Sessions (*Breakout Rooms*)
- 1700 End
(Breakout Rooms available for evening sessions to prepare session summaries until 2100)

Friday, September 30

- 0730 Continental Breakfast (*Lobby of Sandia Vista Conference Center*)
- 0815 Working Group 1 Summary (*Sandia Vista Conference Center*)
- 0845 Working Group 2 Summary (*Sandia Vista Conference Center*)
- 0915 Break
- 0945 Working Group 3 Summary (*Sandia Vista Conference Center*)
- 1015 Working Group 4 Summary (*Sandia Vista Conference Center*)
- 1045 Break
- 1100 Workshop Summary (*Sandia Vista Conference Center*)
- 1130 End Workshop
- 1200 SAG/Working Group Cochairs Meeting—*How Do We Proceed From Here?*

**TERMS OF REFERENCE
MORS SIMULATION VALIDATION SERIES (SIMVAL)**

1994 WORKSHOP ON VV&A

Background

The MORS Simulation Validation Series (SIMVAL) consists of workshops, mini-symposia, advisory group activities, and reports (proceedings) with the purpose of reviewing areas of verification, validation and accreditation (VV&A), determining a consistent set of definitions, developing a general structure and examining the current methodologies. The activities (ongoing since 1990) are directed by a Senior Advisory Group (SAG) which is composed of senior analysts and executives representing a breadth of simulation experience.

The results of the SIMVAL series has been a consistent set of definitions for VV&A, a general structure for VV&A in model/simulation development, and grouping and descriptions of verification and validation methodologies. These results are documented in "Simulation Validation Workshop Proceedings (SIMVAL II)". A copy of these proceeding will be provided to SIMVAL 94 attendees as a part of a read-ahead package.

Objectives

The SIMVAL 94 workshop will address the theme question "How Much V&V is Enough?". The objectives of the workshop are to (1) discuss Service issues in defining and implementing VV&A policy, including "how much VV&A is enough"; (2) within the context of the different levels of models and simulation (M&S), review a limited number of case studies in applying VV&A to discuss the approach and lessons learned; (3) use these lessons learned to develop an initial draft set of guidelines or templates to guide field VV&A efforts. Findings will be documented in an addendum to the MORS VV&A report or as a separate report as appropriate.

The focus of the workshop will be on an exchange of information and ideas on how to develop and implement practical VV&A procedures. Guidelines will be developed based on successes and failures in attempting to define and implement policy across the Services and across different levels of models.

Agenda

The agenda will include an introductory session describing the objectives and scope of the workshop and the results of SIMVAL to date. This will be followed by a plenary session with briefings on each Services' VV&A policy. A panel composed of Service and OSD senior executives will then discuss their experiences in developing and applying VV&A policy.

Selected papers will be presented on approaches and methodology for determining "how much V&V is enough". Topics will include organizational approaches for accreditation, levels of accreditation, Service VV&A guidelines, etc.

On the second day, the workshop will break into five individual sessions pertaining to Engineering level models, engagement level models, mission level models, campaign level models, and Distributed Interactive Simulation.

Each group will focus on broad VV&A issues as well as issues specific to the level of M&S being considered by that group. Group co-chairs will invite presentations on VV&A case studies and organizational approaches to VV&A.

Topics will include:

1. Feasibility and approach to developing VV&A "templates". The purpose of the templates would be to guide users in determining the level of V&V required for different circumstances. Potential template categorization could be a function of the type of decision (test planning, sensitivity analysis, acquisition decision, ...), type of model (engineering, mission, ...), source of model (new code, revision of old code, use of existing model,), etc.
2. V&V of "legacy" models. How much V&V is enough for models that have been in use and accepted by the community?
3. How can the V&V status of a model be presented?
4. What factors can be used to determine whether a model is acceptable for a specific application?

The morning of the third day will be devoted to summarizing major findings of each working group. Findings will be referred by the SAG to determine future actions, such as additional SIMVAL efforts to test and further refine VV&A templates.

The workshop will end at noon 30 September. The Senior Advisory Group will meet until 1700 30 September.

Membership

The workshop co-chairs will be Dr. Marion Williams, FS, of the Air Force Operational Test and Evaluation Center and Mr. James Sikora of BDM International. The chairs will control the membership so that it falls in the range of 75-125. Active use will be made of member of the appropriate MORS working groups, and participants in previous SIMVAL activities will be encouraged to continue their participation. From the applicants responding to the announcement, priority will be

given to those with the most experience in VV&A.

Session co-chairs will moderate session discussions and will take responsibility for preparing and presenting their session summaries. The session co-chair will also be responsible for writing the segment of the MORS SIMVAL report.

The following individuals have agreed to co-chair the individual sessions:

Campaign Level Models	Lt Col Robert Sheldon, USAF Mr. Howard Whitley
Mission Level Models	Ms. Cheryl Black Mr. John Riente
Engagement Level Models	3A Mr. Robert Hartling Mr. Mark Ralston 3B Dr. Paul Muessig Mr Michael Borowski
Engineering Level Models	Dr. Julian Palmore Mr. Robert Eberth
Distributed Interactive Simulation	Mr. William Dunn Mr. Rob Wright

Schedule and Fees

The workshop will be held in Albuquerque, NM at BDM International, Sandia Vista Conference Center September 28-30, 1994.

There will be a registration fee of \$150 for Federal Government employees and \$300 for all others.

**Military Operations Research Society Workshop:
SIMVAL '94
Attendee List (09/29/94)**

Joseph A. Adamo
McDonnell Douglas Aerospace Co
PO Box 516, MC 3065146
St. Louis MO 63166
OFF TEL: (314)-233-2688
FAX: (314)-234-4128

DR John V Adams
IDA
1801 N. Beauregard Street
Alexandria VA 22311-1772
OFF TEL: (703)-845-2475
FAX: (703)-845-6722

MAJ Donald J. Adamson
31 TES OL-KT
8500 Gibson Blvd, SE
Kirtland AFB NM 87117
OFF TEL: (505)-846-2331 DSN: 246-2331
FAX: (505)-846-4285
E-mail: adamsond@p2.afotec.af.mil

Natalie S Addison
Military Operations Research Society
101 S Whiting Street
Suite 202
Alexandria VA 22304-3483
OFF TEL: (703)-751-7290
FAX: (703)-751-8171

Gerald P. Alldredge
BDM International
1801 RANDOLPH S.E.
Albuquerque NM 87106
OFF TEL: (505)-848-5432
FAX: (505)-848-4167

COL Thomas L. Allen
Air Force Studies and Analyses Agency
AFSAA/CC
1570 Air Force Pentagon
Washington DC 20330-1570
OFF TEL: (703)-695-9046 DSN: 225-9046
FAX: (703)-697-3441
E-mail: allentc@afsaa.hq.af.mil

DR David E Anderson
HQ USAF/AFSAA
1570 Air Force, Pentagon
Washington DC 20330-1570
OFF TEL: (703)-695-0725 DSN: 225-0725
FAX: (703)-697-3441
E-mail: anderson@afsaa.HQ.AF.MIL

DR Richard S Baty
BDM International
1801 Randolph Rd, SE
Albuquerque NM 87106
OFF TEL: (505)-848-5337
FAX: (505)-848-5248

List (09/29/94) (cont.)

Pg-2

Francoise Becker
Center for Naval Analyses
4401 Ford Avenue
Alexandria VA 22302-0268
OFF TEL: (703)-824-2526 DSN: 289-2638
FAX: (703)-824-2949
E-mail: beckerf@cna.org

DR Bruce W Bennett
RAND
1700 Main Street
Santa Monica CA 90407-2138
OFF TEL: (310)-393-0411
Ext: 00000667
FAX: (310)-451-7038
E-mail: bruce.bennett@rand.org

Vernon M Bettencourt Jr
The MITRE Corporation
Synthetic Environments Apps Dept
7525 Colshire Drive, MS W641
McLean VA 22102-3481
OFF TEL: (703)-883-7364
FAX: (703)-883-1370
E-mail: vbetten@mitre.org

Cheryl Black
HQ AFOTEC/SAN
8500 Gibson Blvd., SE
Kirtland AFB NM 87117
OFF TEL: (505)-846-0503
FAX: (505)-846-5145

DR Gregory J Born
RAND
1700 Main Street
POB 2138
Santa Monica CA 90407-2138
OFF TEL: (310)-393-0411
Ext: 00000675
FAX: (310)-393-4818
E-mail: gregory_born@rand.org

LCDR Michael Borowski
COMOPTEVFOR
7970 Diven Street
Norfolk VA 23505-1498
OFF TEL: (804)-445-0292 DSN: 565-0292
FAX: (804)-445-8516
E-mail: borowski@tecnet1.jcte.jcs.mil

Edward C Brady FS
Strategic Perspectives, Inc.
7704 Lakeloft Court
Fairfax Station VA 22039
OFF TEL: (703)-250-6338
FAX: (703)-250-3637

David J Brown
Mitre Corporation
7525 Colshire Drive
McLean VA 22102
OFF TEL: (703)-883-5833
FAX: (703)-883-1370

DR Gerry H Cabaniss
BDM International
MS R14
1801 Randolph Road
Albuquerque NM 87106
OFF TEL: (505)-848-5230
FAX: (505)-848-4167
E-mail: gcabaniss@lan.mcl.bdm.com

COL John D Carlile
JTMD/AO
1951 2nd Street, SE
Kirtland AFB NM 87117-5559
OFF TEL: (505)-846-1472 DSN: 246-1472
FAX: (505)-846-1486

Jesus E Carrillo
Research Analysis and Maintenance, Inc.
1790 Lee Trevino Dr, #600
El Paso TX 79936-4525
OFF TEL: (915)-592-7047
Ext: 00000013
FAX: (915)-595-0559

Helga Carter
HQ AFOTEC
Kirtland AFB NM 87117

DR Edward S Cavin
Center for Naval Analyses
PO Box 16268
4401 Ford Avenue
Alexandria VA 22302-0268
OFF TEL: (703)-824-2951 DSN: 289-2638
FAX: (703)-824-2949
E-mail: ccavin@cna.org

LtCol Kevin E Cheek
AFSAA/SAG
1570 Air Force Pentagon
Washington DC 20330-1570
OFF TEL: (703)-614-4247 DSN: 224-4247
FAX: (703)-697-1226
E-mail: cheek@afsaa.hq.af.mil

LTC George T Cherolis
FKJ3-PL-OA
PSC 303, Box 27
Unit 15237
APO AP 96204-0027
OFF TEL: (011)-822-7913 DSN: 723-8371
Ext: 00000824
FAX: (011)-822-8244
E-mail: cfcd-pl-oa@emh7.korea.army.mil

Willard M Christenson
Institute for Defense Analyses
SFRD Room 517
1801 N. Beauregard St
Alexandria VA 22311
OFF TEL: (703)-845-2439
FAX: (703)-845-2255
E-mail: wchriste@ida.org

Julie C Chu
US Army Armament Rsch Dev & Engineer Ctr
ATTN: SMCAR-ASH
Picatinny Arsenal NJ 07806-5000
OFF TEL: (201)-724-7088 DSN: 880-7088
FAX: (201)-724-4111
E-mail: jchu@pica.army.mil

Gary Q Coe
ANSER
1215 Jefferson Davis Hwy
Suite 800
Arlington VA 22202
OFF TEL: (703)-416-3073
FAX: (703)-416-3389
E-mail: coeg@ANSER.org

Allan L Collie
BDM International
1801 Randolph Road, SE
Albuquerque NM 87106
OFF TEL: (505)-848-5231
FAX: (505)-848-5809

Capt Angie Crawford
AFOTEC/SAN
Kirtland AFB NM 87117
OFF TEL: (505)-846-1377 DSN: 246-1377
FAX: (505)-846-5145
E-mail: crawfora@pl.afotec.af.mil

Kevin R Crosthwaite
Booz Allen & Hamilton
4141 Colonel Glenn Hwy
Suite 131
Dayton OH 45431
OFF TEL: (513)-429-9509
FAX: (513)-429-9795

Keith P Curtis
The MITRE Corporation
7525 Colshire Dr
MS Z464
McLean VA 22102-3481
OFF TEL: (703)-883-7905
FAX: (703)-883-1379
E-mail: kcurtis@mitre.org

Joseph J Cynamon
The MITRE Corporation
C3I Division, D-46 MS 1302
202 Burlington Post Road
Bedford MA 01730
OFF TEL: (617)-377-5550 DSN: 478-5550
FAX: (617)-271-7469
E-mail: joe_cynamon.masc@qrnbase.mitre.org

Michael H Davis
Det 4 505 CCEG
Room 210
1655 First Street, SE
Kirtland AFB NM 87117-5617
OFF TEL: (505)-846-2391 DSN: 246-2391
FAX: (505)-846-1486

Vincent E Debban
Booz, Allen and Hamilton
Suite 600
1953 Gallows Road
Vienna VA 22182
OFF TEL: (703)-902-6953
FAX: (703)-902-7171

Carrol R. Denney
TRADOC Analysis Center-WSMR
Attn: ATRC-WEB
White Sands Missile Range NM 88002-5502
OFF TEL: (505)-678-6778 DSN: 258-6778
FAX: (505)-678-5104
E-mail: denneyc@wsmr-emh91.army.mil

DR James A Dewar
RAND
1700 Main Street
Santa Monica CA 90407-2138
OFF TEL: (213)-393-0411
Ext: 00000755
FAX: (213)-393-4818
E-mail: dewar@rand.org

George T Dietrich Jr
Booz Allen & Hamilton
Suite 300
2201 Buena Vista Drive, SE
Albuquerque NM 87111
OFF TEL: (505)-247-8722
FAX: (505)-242-4821
E-mail: DIETRICH_GEOERGE@bah.com

Robert D Dighton
Institute for Defense Analyses
1801 N. Beauregard Street
Alexandria VA 22311-1772
OFF TEL: (703)-845-6992
FAX: (703)-845-6911
E-mail: rdighton@ida.org

DR Henry C Dubin
US Army Operational Test & Eval Comd
Attn: CSTE-ZT
4501 Ford Avenue
Alexandria VA 22302-1458
OFF TEL: (703)-756-2367 DSN: 289-2367
FAX: (703)-756-0779
E-mail: dubin@text1@texcom-emh1.army.mil

Capt Ross A. Dudley
31 TES, OL-KT
8500 Gibson Blvd, SE
Kirtland AFB NM 87117-5558
OFF TEL: (505)-846-5328 DSN: 246-5328
FAX: (505)-846-4285
E-mail: dudleyr@p2.afotec.af.mil

James B Duff
COMOPTEVFOR
Technical Director, Code 00T
7970 Diven Street
Norfolk VA 23505-1498
OFF TEL: (804)-444-5197 DSN: 564-5197
FAX: (804)-445-9174
E-mail: duff@tecnet1.jcte.jcs.mil

William H Dunn
US Army MISMA
Crystal Square 2, #808
1725 Jefferson Davis Hwy
Arlington VA 22202
OFF TEL: (703)-607-3384 DSN: 327-3384
FAX: (703)-607-3381
E-mail: william.h.dunn@pentagon-1dms18.army.mil

Robert A Eberhard
Institute for Defense Analyses
1801 N. Beauregard Street
Alexandria VA 22311
OFF TEL: (703)-845-6939
FAX: (703)-845-6911
E-mail: <reberhar@oed-ul.ida.org>

Robert W Eberth
Palmer-Eberth
Suite 115-212
1350 Beverly Road
McLean VA 22101
OFF TEL: (703)-769-3325
FAX: (703)-685-9849

DR Sharon Ellis
ENTEK, Inc
2201 Buena Vista, SE
Albuquerque NM 87106
OFF TEL: (505)-242-5860
FAX: (505)-242-7034

DR Henry L Eskew
Center for Naval Analyses
4401 Ford Ave
Alexandria VA 22302
OFF TEL: (703)-824-2254 DSN: 289-2638
FAX: (703)-824-2949

Joseph L Faix
TRW
JTMD/AO
1951 2nd Street SE
Kirtland AFB NM 87117-5559
OFF TEL: (505)-846-6846 DSN: 246-6846
FAX: (505)-846-6843

LtCol Coral Fallstead
AFOTEC/OL-PC
National Test Facility
730 Irwin Ave, Room 2309-1
Falcon AFB CO 80912-7300
OFF TEL: (719)-380-3695 DSN: 749-3695

Peter D. Feuerstein
US Army Space & Strategic Defense Cmd
Attn: CSSD-SA-T
105 Colt Circle
Huntsville AL 35811
OFF TEL: (205)-955-1682 DSN: 645-1682
FAX: (209)-955-4339

List (09/29/94) (cont.)

Pg-6

Christine A Fossett
US GAO
Office of Policy, Room 6800
441 G Street, NW
Washington DC 20548
OFF TEL: (202)-512-2956
FAX: (202)-512-4844

Donald L. Gillett
SAIC
4242 Woodcock Drive, Suite 150
San Antonio TX 78228
OFF TEL: (210)-731-2220
FAX: (210)-731-2297

Peggy Gordon
HQ USAF/XOMT
1480 Air Force Pentagon
Washington DC 20330-1480
OFF TEL: (202)-504-5339 DSN: 285-5339
FAX: (202)-504-5352
E-mail: pgordon@xom-mail.hq.af.mil

Cheryl Grant
Illgen Simulation Technologies, Inc
Suite 10
250 Storke Road
Goleta CA 93117
OFF TEL: (805)-562-3866
FAX: (805)-968-1311

Jimmy R Grussmeyer
SRS Technologies
Washington Operations Div
1500 Wilson Blvd, #800
Arlington VA 22209
OFF TEL: (703)-522-5588
FAX: (703)-527-3807

James E Haile
AFMC Office of Aerospace Studies
COEA Support Division
3550 Aberdeen Ave
Kirtland AFB NM 87117-6008
OFF TEL: (505)-846-8302 DSN: 246-8302
FAX: (505)-846-4668

David H Hall
Naval Air Warfare Center
Weapons Div, Code C21805
1 Administration Circle
China Lake CA 93555-6001
OFF TEL: (619)-927-1297 DSN: 469-1297
FAX: (619)-939-2062

James L. Hanger Jr.
Aerospace Corp
The Hallmark Building, Suite 187
13873 Park Center Road
Herndon VA 22071
OFF TEL: (703)-318-1751
FAX: (703)-318-5409

MajGen George B Harrison
HQ AFOTEC/CC
8500 Gibson Blvd, SE
Kirtland AFB NM 87117-5558
OFF TEL: (505)-846-4533 DSN: 246-4533
FAX: (505)-846-9726
E-mail: harrisonge@hq.afotec.af.mil

DR Dean S Hartley III
Martin Marietta Energy Systems
Data Systems R&D Program
1099 Commerce Park
Oak Ridge TN 37830
OFF TEL: (615)-574-7670
FAX: (615)-574-0792
E-mail: dhx@ornl.gov

List (09/29/94) (cont.)

Pg-7

Robert G Hartling
Chief of Naval Operations (N812D)
2000 Navy Pentagon
Room 4A522
Washington DC 20350-2000
OFF TEL: (703)-695-3797 DSN: 225-3797
FAX: (703)-693-9760
E-mail: rhart@dmso.dtic.dla.mil

DR Kent Haspert
IDA
1801 N. Beauregard Street
Alexandria VA 22311
OFF TEL: (703)-845-2427
FAX: (703)-845-6911

MSgt Leon F Hass
AFOTEC/OL-PC
730 Irwin Ave
Falcon AFS CO 80912-7300
OFF TEL: (719)-380-3238 DSN: 749-3238
FAX: (719)-380-3108
E-mail: lhass@inet.ntf1.af.mil

DR Dale B Henderson
Los Alamos National Laboratory
A Division
MS F606
Los Alamos NM 87545
OFF TEL: (505)-665-2151
FAX: (505)-665-5204
E-mail: dbh@lanl.gov

Capt Phillip A. Herre
31 TES OL-KT
8500 Gibson Blvd, SE
Kirtland AFB NM 87117
OFF TEL: (505)-846-5329 DSN: 246-5328
FAX: (505)-846-4285

Stephen Hobbs
NCCOSC
Code 784
San Diego CA 92152-5001
OFF TEL: (619)-553-2018
FAX: (619)-553-1635
E-mail: hobbs@nosc.mil

MAJ Cyrus E Holliday
TRADOC, Threat Support Division
Attn: ATZL-CST
Bldg 53, 700 Scott Ave
Fort Leavenworth KS 66027-1323
OFF TEL: (913)-684-7974 DSN: 552-7974
FAX: (913)-684-2397
E-mail: hollidac@leal-emn.mil

Roger K Hoppe
TASC
2017 Yale Avenue
Albuquerque NM 87106
OFF TEL: (505)-764-8782
FAX: (505)-764-8754

MAJ Brian Ishihara
HQ USAF/TEP
1530 Air Force Pentagon
Washington DC 20330-1530
OFF TEL: (703)-695-0900 DSN: 225-0900
FAX: (703)-695-0803
E-mail: ishiharb@tep.hq.af.mil

MAJ Edward B Janeczko Jr
513th Engineering & Test Squadron
901 SAC Blvd Suite 1H1
Offutt AFB NE 68113-5520
OFF TEL: (402)-294-7027 DSN: 271-7027
FAX: (402)-294-6526

DR Anil N Joglekar
Institute for Defense Analyses
1801 Beauregard St
Alexandria VA 22311
OFF TEL: (703)-845-2343 DSN: 289-1825
FAX: (703)-845-6977
E-mail: ajoglekar@ida.org

Larry J Jurica
The MITRE Corporation
234 South Fraly Blvd
Suite 100
Dumfries VA 22026
OFF TEL: (703)-441-1775
FAX: (703)-441-1779

MAJ Jeffrey R Kass
OSD, JADO/JEZ, MOD/SIM Branch
307 West Van Matre Ave
Eglin AFB FL 32542-6805
OFF TEL: (904)-882-5221 DSN: 872-5221
FAX: (904)-882-6215

Irwin A Kaufman
Institute for Defense Analyses
1801 N. Beauregard
Alexandria VA 22311
OFF TEL: (703)-845-2486 DSN: 289-1868
FAX: (703)-845-6911
E-mail: ikaufman@ida.org

Carl D Keim
BDM International, Inc
1801 Randolph Road, SE
Albuquerque NM 87106
OFF TEL: (505)-848-5368 DSN: 246-4682
FAX: (505)-846-1872

Charles Lee Kirby
US Army TRAC-WSMR
ATTN: ATARC-WJ
White Sands Missile Range NM 88002-5502
OFF TEL: (505)-678-1950 DSN: 258-1950
FAX: (505)-678-5104
E-mail: kirby@wsmr-emh91.army.mil

James C Kolding
Teledyne Brown Engineering
300 Sparkman Dr., NW
PO Box 070007, MS #170
Huntsville AL 35807-7007
OFF TEL: (205)-726-2893
FAX: (205)-726-2241
E-mail: jkolding@pobox.tbe.com

LtCol Kenneth C. Konwin
JAST/PIA

OFF TEL: (703)-602-7390 DSN: 332-7390
Ext: 00000664
FAX: (703)-416-8440
E-mail: konwink@ntrprs.jast.mil

Ann Krause
HQ AFOTEC/SAN
8500 Gibson Blvd., SE
Kirtland AFB NM 87117-5558
OFF TEL: (505)-846-2846 DSN: 246-2846
FAX: (505)-846-5145
E-mail: krausea@pl.afotec.af.mil

Philip R Landweer
BDM International
MS R-34
1801 Randolph Road, SE
Albuquerque NM 87106
OFF TEL: (505)-848-5251
FAX: (505)-848-4047
E-mail: plandwee@abq.bdm.com

List (09/29/94) (cont.)

Pg-9

Kenneth E Lavoie
Air Force Wargaming Center
AUCADRE/WGT
Bldg 1406
Maxwell AFB AL 36112-5532
OFF TEL: (205)-953-6528 DSN: 493-6528
FAX: (205)-953-2593
E-mail: lavoie@cadre.af.mil

Richard R Ledesma
OSD, OUSD(A&T)/DDT&E/A&SP
The Pentagon, Room 3D1075
Washington DC 20301-3110
OFF TEL: (703)-695-7245 DSN: 225-7245
FAX: (703)-614-7040

DR Gregory A Mack
Booz Allen & Hamilton
Advanced Decision Systems Div

Daniel McDonough
AFOTEC/SAN
8500 Gibson Blvd, SE
Kirtland AFB NM 87117-5558
OFF TEL: (505)-846-1359 DSN: 246-1359
FAX: (505)-846-5145
E-mail: mcdonoud@pl.afotec.af.mil

MAJ Steven A. Minarik
MARCORSYSCOM
POB 156
Quantico VA 22134
OFF TEL: (703)-640-3634 DSN: 278-3634
FAX: (703)-640-2168
E-mail: minarik@psa@marcordsyscom

William P. Leavenworth
SAIC
c/o OSD JACO/JEZ
307 W. Van Matre Avenue, Suite 105
Eglin AFB FL 32542-6805
OFF TEL: (904)-882-5221 DSN: 872-5221
FAX: (904)-882-6215

COL Gordon A. Long
NORAD/USSPACECOM/AN
Suite 116
250 South Peterson Blvd
Peterson AFB CO 80914-3180
OFF TEL: (719)-554-3638 DSN: 692-3638
FAX: (719)-554-5068
E-mail: glong@spacecom.af.mil

DR Hugo E Mayer
TRAC Operations Analysis Center
ATTN: ATRC-FSD
Fort Leavenworth KS 66027
OFF TEL: (913)-684-6872 DSN: 552-6872
FAX: (913)-684-4368
E-mail: mayerh@tracer.army.mil

Robert E Mercer
US Army Operational Evaluation Command
4501 Ford Avenue
Alexandria VA 22302-1458
OFF TEL: (703)-756-1816 DSN: 289-1819
FAX: (703)-756-7586

DR Richard B Modjeski
Operational T&E Command
Park Center 4
4501 Ford Ave
Alexandria VA 22302-1458
OFF TEL: (703)-602-6038 DSN: 332-6039
FAX: (703)-602-6041

List (09/29/94) (cont.)

Pg-10

DR Paul R Muessig
Naval Air Warfare Center
Code 318
Weapons Div
China Lake CA 93555-6001
OFF TEL: (619)-927-1271 DSN: 469-1271
FAX: (619)-939-2062

Allen M Murashige
AFSAA/SAT
Scientific & Technical Advisor
1570 Air Force Pentagon
Washington DC 20330-1570
OFF TEL: (703)-697-5795 DSN: 227-5795
FAX: (703)-697-3441
E-mail: murashige@afsaa.hq.af.mil

Patty O'Brien
HQ AFOTEC/SAN
8500 Gibson Blvd., SE
Kirtland AFB NM 87117-5558
OFF TEL: (505)-846-2845 DSN: 246-2845
FAX: (505)-846-5145
E-mail: obrienc@p1.afotec.af.mil

Capt Juan C. Ortiz
31 TES, OL-KT
8500 Gibson Blvd, SE
Kirtland AFB NM 87117-5558
OFF TEL: (505)-846-5328 DSN: 246-5328
FAX: (505)-846-4285
E-mail: ortizj@p2.afotec.af.mil

DR Julian I Palmore
US Army Construct Engineer Rsch Lab
PO Box 9005
Champaign IL 61826-9005
OFF TEL: (217)-352-6511
Ext: 00000768
FAX: (217)-373-6724
E-mail: palmore@osiris.cso.uiuc.edu

Steve Payne
DIA
Missile and Space Intel Center
Attn: DIA/MSC-6B
Redstone Arsenal AL 35898-5500
OFF TEL: (205)-313-6231
FAX: (205)-313-6267

DR Albert E. Rainis
OSD/OUSD(A&T)/TWP
Pentagon
Washington DC 20330-3100
OFF TEL: (703)-697-8183 DSN: 227-8183
FAX: (703)-614-7060
E-mail: rainisac@acq.osd.mil

Mark H Ralston
US Army AMSAA
Attn: AMXSY-SL
Aberdeen Proving Ground MD 21005-5071
OFF TEL: (410)-278-6577 DSN: 298-6577
FAX: (410)-278-2788
E-mail: ralston@arl.mil

David J Reed
IITRI
185 Admiral Cochrane Drive
Annapolis MD 21401
OFF TEL: (410)-573-7709
FAX: (410)-573-7760
E-mail: reedd@jsc.mil

John A Riente
HQ Department of the Army
Deputy Chief of Staff for Ops & Plans
400 Army Pentagon
Washington DC 20310-0400
OFF TEL: (703)-697-4113 DSN: 227-4113
FAX: (703)-614-9044
E-mail: riente@pentemh2.army.mil

John R Robbins
Technical Solutions Inc.
PO box 1148
Mesilla Park NM 88047
OFF TEL: (505)-524-2154
FAX: (505)-525-5801

DR Patricia A Sanders
OSD(PA&E)
Land Forces
Pentagon, Room 2B256
Washington DC 20301-1800
OFF TEL: (703)-697-3521 DSN: 227-3521
FAX: (703)-693-5707
E-mail: pas@dmso.dtic.dla.mil

Raybon Sanderson
BDM
1801 Randolph SE
Albuquerque NM 87106
OFF TEL: (505)-848-5387

MAJ Joseph R. Schwab
STRICOM
Attn: AMCPM-CATT
12350 Research Parkway
Orlando FL 32826
OFF TEL: (407)-384-3226
FAX: (407)-384-3223
E-mail: schwabj@stricom.army.mil

DR Ernest A. Seglie
DOT&E/OSD
Pentagon, Room 3E318
1700 Defense Pentagon
Washington DC 20301-1700
OFF TEL: (703)-697-7247 DSN: 227-7247
FAX: (703)-693-5248
E-mail: seglie-ernest@mail-host.dote.osd.mil

DR John C Sessler
BMDO/AQM
The Pentagon, Room 1E149
Washington DC 20301
OFF TEL: (703)-693-1594
FAX: (703)-693-1700

LtCol James F Sheedy
HQ AFOTEC/TF
Kirtland AFB NM 87117
OFF TEL: (505)-846-5326 DSN: 246-5326
FAX: (505)-846-5301

LtCol Robert S Sheldon
AFSAA/SAZ
The Pentagon, Room 1E386
Washington DC 20330-5420
OFF TEL: (703)-693-8423 DSN: 227-8423

Sheryl L. Shoupe
BDM International
1801 Randolph Road, SE
Albuquerque NM 87106
OFF TEL: (505)-848-5650

James J Sikora
BDM International
MS B10
1801 Randolph Road, SE
Albuquerque NM 87106
OFF TEL: (505)-848-5650
FAX: (505)-848-4051
E-mail: sikora@salsa.abq.bdm.com

List (09/29/94) (cont.)

Pg-12

Susan D Solick
US Army TRAC-OAC
Attn: ATRC-FCA
Fort Leavenworth KS 66027-5200
OFF TEL: (913)-684-6868 DSN: 552-6868
FAX: (913)-684-4368
E-mail: solicks@tracer.army.mil

Edward N. Sowell
HQ TEXCOM
Headquarters Avenue, Bldg 91012
Fort Hood TX 76544-5065
OFF TEL: (817)-288-1845 DSN: 738-1845
FAX: (817)-288-1644
E-mail: txh2437@texcom-emh1.army.mil

DR Walter L Stanley
BDM International
1801 Randolph Rd, SE
Albuquerque NM 87106
OFF TEL: (505)-848-5594
FAX: (505)-848-5528
E-mail: stanley @ abq.bdm.com

Capt John Stephenson
HQ AFOTEC/SAN
8500 Gibson Blvd., SE
Kirtland AFB NM 87117-5558
OFF TEL: (505)-846-7840 DSN: 246-7840
FAX: (505)-846-5145
E-mail: stephan@pi.afotec.af.mil

Morris A Stringfield
ATCOM, Dept of the Army
AMSAT-D-BA
4300 Goodfellow Blvd
St Louis MO 63120
OFF TEL: (314)-263-3763 DSN: 693-3763
FAX: (314)-263-1148

LTC Howard Taylor
National Simulation Center
Technical Support Director
ATTN: ATZL-NSC-T
Fort Leavenworth KS 66027-7305
OFF TEL: (913)-684-8184 DSN: 552-8184
FAX: (913)-684-8171
E-mail: taylorrl@leav-emh.army.mil

Clayton J Thomas FS
AFSAA/SAN
1570 Air Force Pentagon
Room 1E386
Washington DC 20330-1570
OFF TEL: (703)-697-4300 DSN: 227-4300
FAX: (703)-697-3441
E-mail: thomasc@afsaa.hq.af.mil

LtCol David S Thomen
Marine Corps Combat Development Command
Studies and Analysis Division
3093 Upshur Ave
Quantico VA 22134-5130
OFF TEL: (703)-640-3235 DSN: 278-3235
FAX: (703)-640-3547
E-mail: dthomen@dmso.dtic.dla.mil

Van D Underwood
Johns Hopkins University/APL
13550 Stowe Drive
Poway CA 92064
OFF TEL: (619)-486-5857
FAX: (619)-486-6201
E-mail: Underwood, VanD@cmpwest.edu

MAJ Stephen C Upton
Marine Corps Combat Development Command
Studies and Analysis Division
3093 Upshur Ave
Quantico VA 22134-5130
OFF TEL: (703)-640-3235 DSN: 278-3235
FAX: (703)-640-3547
E-mail: uptons@mqq-smtp1.usmc.mil

Eugene P Visco FS
US Army MISMA
Crystal Square 2, #808, SFUS-MIS
1725 Jefferson Davis Hwy
Arlington VA 22202
OFF TEL: (703)-607-3420 DSN: 327-3420
FAX: (703)-607-3381
E-mail: Eugene.P.Visco@Pentagon-1dms18.army.mil

Howard G Whitley III
US Army Concepts Analysis Agency
8120 Woodmont Ave
Attn: CSCA-TCT
Bethesda MD 20814-2797
OFF TEL: (301)-295-1611 DSN: 295-1611
FAX: (301)-295-1287
E-mail: whitley@caa.army.mil

Richard I Wiles
Military Operations Research Society
101 S Whiting Street
Suite 202
Alexandria VA 22304
OFF TEL: (703)-751-7290
FAX: (703)-751-8171
E-mail: rwiles@dgis.dtic.dla.mil

DR Marion L Williams FS
HQ AFOTEC Chief Scientist
8500 Gibson Blvd, SE
Kirtland AFB NM 87117-5558
OFF TEL: (505)-846-0607 DSN: 246-0607
FAX: (505)-846-9726
E-mail: williamsm@hq.afotec.af.mil

Floyd C. Wofford
US Army Materiel Systems Analysis Acty
ATTN: AMXSY-CD
Aberdeen Proving Ground MD 21005-5071
OFF TEL: (410)-278-5358 DSN: 298-5358
FAX: (410)-278-6585

DR Robert H Wright
Resource Consultants, Inc.
3051 Technology Pkwy, #280
Orlando FL 32826
OFF TEL: (407)-282-1451
FAX: (407)-658-9541
E-mail: wright@dmsc.dtic.dla.mil

